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Cross-age tutoring and young children's spatial problem-solving skills in a Logo programming environment

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CROSS-AGE TUTORING AND YOUNG CHILDREN'S SPATIAL PROBLEM SOLVING SKILLS IN A LOGO PROGRAMMING ENVIRONMENT

by

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APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro.

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Twenty-eight six to eight year old children enrolled in a summer enrichment program in a southeastern urban public elementary school were randomly assigned to three groups of tutors: (a) same-age (6-8 years of age); (b) near same-age (9-12 years of age); and (c) college age (18-21), to assess their ability to successfully complete three stages of Logo training (i.e., Logo positioning commands (Stage I), Direct Route Strategies (Stage II), and Indirect Route Strategies (Stage III). Twelve 30-minute training sessions were videotaped over a three week period to provide additional descriptive data.

It was expected that all subjects would be able to complete all three stages of training in three weeks and that children who received tutoring from the college age students would be more efficient and proficient in solving the specially designed spatial problems. Data were analyzed for the amount of time taken to successfully complete a problem, number of errors, number and size of turtle steps, and number and size of angles selected.

Results of a one-way ANOVA, for each of the three tutor age categories, revealed that there were no significant differences between the children in their time to successfully complete a problem nor were there any significant differences between the children in the number of errors made. A one-way ANOVA revealed a significant

difference between the groups in their use of small (FD 10 versus FD 30) turtle steps. Scheffe's multiple comparisons test showed significant differences in small turtle steps between the children tutored by same-age peers and those tutored by college age students. Analyses of the means revealed that the children tutored by college age students used more small turtle steps than did children tutored by same-age peers. Separate one-way ANOVAs revealed that there were no significant differences between the children in their use of large turtle steps (FD 30), small angles (45 degrees), or large angles (90 degrees).

Analyses of the frequency distributions of the tutors teaching behaviors revealed that the tutors were more likely to use an "initiate" type behavior during the first week of training. By the third week there was an increase in the number of "elicit" type behaviors for all groups and a noteworthy difference between the groups in the use of "initiate" type behaviors. The near same-age peers and college age students used substantially more "initiate" type behaviors than did the same-age tutors.

It was concluded that all (28) of the subjects were able to successfully complete Stage I, five successfully completed Stage II, and three successfully completed Stage III, in three weeks of training, regardless of the tutors' age category.

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Finally, I share this accomplishment with those who came before me, those who helped me along the way, and with those yet to come.

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CHAPTER I

BACKGROUND

In an era of rapidly decreasing financial resources and rising expectations for learning outcomes, more and more attention is being directed toward maximizing efficient use of available resources. Existing literature written (Slavin, 1987; Webb, 1987) on peer teaching and tutoring suggests that cooperative learning methods, where both tutor and tutee learn, are consistently more cost effective and uncomplicated to implement. The one abundant and readily available resource schools have is their students. A relatively easy classroom strategy a teacher could use would be to augment her traditional teaching methods with a systematic and well integrated use of cross-age tutoring. Use of this method alone, however, would not suffice.

A significant element of the teaching role is the nature of the interactions between the teacher and the student. At the core of any tutorial relationship is the often expressed purpose of acquiring or building one or more skills that would enhance the student's achievement and performance. Often, problem solving skills are the focus of tutorial relationships. Even though a specific task may constitute the basis for initiating a tutorial relationship, much of the interactions between teacher and student is of a problem solving, skill acquisition nature. Wood, Bruner, and Ross (1976) suggest that "tutorial interactions are, in short, a crucial feature of infancy and childhood". More directly, it is through adults or capable peers helping that younger children become more skillful.

In today's increasingly technological society, such cognitive skills as remembering, reasoning, and problem solving are essential to the educational process and to educational success. Educational leaders across the country are cognizant of the urgent need for young children to have the skills necessary to function in an increasingly technological society. The advent of computers and other technological resources made available in our schools dictates a need for "higher order" thinking skills.

The rapid introduction of computers in schools, a significant innovation in its own right, has to some extent altered the teaching and learning process. Very germane to the use of computers is the vital role of software used to perform needed and specific functions. The first computer programs used in classrooms around the country were of the Computer-Aided-Instruction (CAI) variety. These canned programs were designed to primarily serve a drill and practice function. Subsequently, greater attention was directed at developing ways for students to exercise more control in their interactions with computers than was feasible with CAI.

Seymour Papert (1980) and his colleagues at the Massachusetts Institute of Technology, credited with creating the popular computer programming language LOGO, generated enthusiasm and research interest about how learning to program might augment children's thinking, learning and problem solving (Clements & Gullo, 1984; Emihovich & Miller, 1986; Pea & Kurland, 1984; Shade & Watson, 1985, 1987; Brinkley & Watson, 1986; Watson, Lange & Brinkley, 1989). Although some researchers (Clements & Gullo, 1984; Lochhead, 1979; Papert, 1980; Soloway, Lochhead, & Clement, 1982) suggest that cognitive skills can be taught using computer programming, evidence to support these propositions appear inconsistent.

In general, the available research on the cognitive benefits of computer programming appear to fall into one of two major fields of thought. One camp of researchers (Dalbey & Linn, 1986; Kurland & Pea, 1984; Pea & Kurland, 1985) contend that young children are unable to learn to program using Logo. They argue that this position is supported by their findings that show young children are unable to transfer the skills they use in the Logo environment to other contexts. By contrast, researchers in the other camp (Papert, 1980; Brinkley & Watson, 1989; Easton & Watson, 1989; Fay & Mayer, 1987; Mayer & Fay, 1987; Watson & Busch, 1989; Watson, Lange & Brinkley, 1989) argue that young children do learn to program in Logo and in some instances (Watson, Lange & Brinkley, 1989) they are able to transfer their skills in a non-computer screen environment. Watson et. al. point out that it is not necessary for children to fully understand programming to move around the computer screen. It appears that early reactions to Papert's claims that young children could learn to program with Logo and such programming could help develop their problem solving skills led many researchers to narrowly define "learning". If one accepts that learning only takes place when a transfer of skills across various contexts can be applied, it is easy to imagine how the early respondents came to their conclusions about the cognitive outcomes of young children learning to program.

Empirical research on the cognitive benefits of Logo training, specifically, has picked up momentum since Papert's claims about the advantages of this "powerful learning tool". Watson, Lange, & Brinkley (1989) initiated research to examine short and long term effects of Logo training on young children's problem solving skills. While this research adds valuable information to the existing literature, gaps remain. Many uncertainties exist concerning what different variables in the Logo environment most significantly influence problem solving skills. One such uncertainty concerns the effects of student-teacher match or teacher variables in the learning environment. Given the increasing demands on teachers, decreases in available resources, and the readiness with which young people approach a computer environment, peers as mediators, teachers, or tutors may offer a viable supplement to quality teaching in the classroom setting.

The social context of learning has been amply addressed both in education (Emihovich & Miller, 1986; in press) and psychology (Bruner & Kennedy, 1966; Vygotsky, 1978) as a major contributing factor to cognition. However, little empirical research has been undertaken to examine how children can teach one another problem solving skills in a Logo environment (Guntermann & Tovar, 1987). The Logo programming language is open-ended and lends itself to the young problem solver as well as the advanced programmer. Cooperative learning has been shown to benefit both the tutor and tutee (Slavin, 1987). These conditions would appear to make it possible to support efforts to augment traditional classroom instruction with cross-age tutoring.

Statement of the Problem

Although cross-age tutoring has received positive reviews (Slavin, 1987) concerning its usefulness, little, if any, empirical research has been conducted to examine the effectiveness of young children, adolescents, or adults as tutors in a computer context. The potential value of matching learners and teachers based on chronological age congruence is unclear if not unknown. In this age of computers where children seem easily engaged and ready to experiment, several legitimate questions emerge: (a) Can young children learn a set of basic Logo programming commands through peer tutoring? (b) Are the learning outcomes the same for young children regardless of whether their tutor is a same-age peer, a near same-age peer, or a college age student? (c) Can young children tutored by same-age peers, near same-age peers, or college age students learn 14 positioning commands with as little as two hours, i.e., four 30 minute sessions of training?

Definition of Terms

1. Cross-age tutoring refers specifically to instruction and assistance provided to 6-8 year olds by persons in one of the following age categories: (a) 6-8 years; (b) 9-12 years; or (c) college age.
2. Learning refers to a subject's demonstrated ability to replicate a spatial pattern by transposing what he or she sees on "training" or "test" cards (see Appendix) to the computer screen. Exact replications were not expected, but approximate facsimiles of three out of four test cards that had the same number of "legs" (lines), with the head of the "turtle" (cursor) in the

same direction, with the starting point in the same quadrant of the computer screen, and the correct angle(s) selected for turns or rotations were considered to be evidence of learning.

3. Logo environment refers to a "microworld" or "mental set" in which a child can freely manipulate the "turtle" cursor about a computer screen (Papert, 1980; Watson & Busch, 1989).

4. Logo training refers to specific instruction regarding Logo positioning commands (eg., start, forward, backward 10 steps, etc.) and the use of a string of commands to solve specially designed spatial problems.

Hypotheses

1. There will be no significant differences found in the learners time to complete a task when compared by the teacher age categories.

2. There will be no significant differences found in the learners number of errors when compared by the teacher age categories.

3. There will be no significant relationships found between the learners time to complete a task and the number of errors made.

4. There will be no significant differences found in the learners frequency of use of small turtle steps when compared by the teacher age categories.

5. There will be no significant differences found in the learners frequency of use of large turtle steps when compared by the teacher age categories.
6. There will be no significant differences found in the learners frequency use of small angles (45 degrees) when compared by the teacher age categories.
7. There will be no significant differences found in the learners frequency of use of large angles (90 degrees) when compared by the teacher age categories.

Limitations

Several factors restricted the research report herein. First, access to 6-8 and 9-12 year old students for a six weeks period was problematic. The regular academic year was deemed infeasible because of the structure of the elementary schools in the selected region. Some schools had only K-3 grades, and others that had K-6 grades did not have the computer resources that were necessary for this research or did not have an after school enrichment program. A summer enrichment program operated by the local school system provided the greatest amount of flexibility for structuring and implementing this research study. A major problem developed soon after the study began, an unexpected high level of subject mortality. Many of the children who initially indicated interest in participating either did not register for the first two of three 3-week sessions, were withdrawn for one or more weeks vacation, or wanted to participate in some other concurrent program activity.

In some cases the younger children wanted to participate if, and only if, their friends participated. Similarly, several children wanted to be matched with their friends. Also, in the case of multiple sibling groups, the experimenter had to avoid matching siblings, which reduced the sample pool.

Finally, incentives became necessary to keep the children interested for six weeks. The investigator provided popcorn, cheez puffs, "Now or Later" candy (a very popular candy among young children) and other treats, as well as an opportunity to play an EZ Logo game of a child's choice, as rewards for participating in a session. Successful completion of a training task was not a requirement to receive a treat, only active participation throughout a 30 minute session. Activities needed to be fun and exciting and not too difficult. The children were quite cognizant of their summer vacation and their freedom to withdraw from this research at any time without any adverse consequences.

CHAPTER II

REVIEW OF RELATED LITERATURE

Young Children and Logo Programming

Several recent studies (Brinkley & Watson, 1986; Clement & Gullo, 1984; Emihovich & Miller, 1986, in press; Papert, 1980; Shade & Watson, 1985, 1986; Watson, Lange, & Brinkley, in prep.) indicate that young children are able to learn a variety of concepts and skills using Logo. Children as young as three years successfully learned to operate difficult software (Shade & Watson, 1985) and "sorting" objects (putting like objects together) (Brinkley & Watson, 1986). Papert (1980) stated that young children could learn to program with Logo and this experience could change how they thought in general. Some research (Pea & Kurland, 1984) investigating Papert's claim showed that the claims for cognitive benefits coming from Logo programming are generally unsubstantiated, because children in these studies failed to transfer what they learned from Logo programming to a non-computer task. More recent research findings (Brinkley & Watson, 1989; Easton & watson, 1989; Fay & Mayer, 1987; Mayer & Fay, 1987; Watson, Lange & Brinkley, 1989) provide evidence that young children can learn to program and solve age-appropriate problems when the emphasis is on problem solving versus programming. These findings also support Papert's claims that young children can use the turtle cursor as a tool with which to think. Overall, these inconsistent findings about what young children learn with Logo instruction provided impetus for further investigation and inquiry.

A series of research studies at the University of North Carolina at Greensboro (Brinkley & Watson, 1987; Calvert, Watson , Brinkley, & Bordeaux, 1987; Lipinsky, Nida, Shade, & Watson, 1986; Shade, Nida, Lipinsky, & Watson, 1986; Shade & Watson, 1987; Watson, Chadwick, & Brinkley, 1986; Watson, Calvert, & Popkin, 1986) were designed to investigate the relationship between cognitive style and programming, as well as address interactive learning/teaching with a microcomputer paradigm. Results from these studies indicate that young children can use computer technology, specifically programming activities, to accelerate learning and this paradigm can promote reorganization of cognitive processing (Watson, Lange, & Brinkley, 1987). In all of these studies adults were the teachers and they provided instruction.

Emihovich and Miller (1986) pointed out that children's learning with Logo should reflect Logo as a "context" for learning versus Logo as simply a tool for learning or method of instruction. They strongly argue that learning Logo creates a social context for cognitive development and future research should focus on the process of learning as well as outcomes of learning with computers. Their research, designed to assess young children's metacognitive (self-monitoring, evaluation of one's own knowledge) skills, included the use of videotapes and discourse analysis to explain qualitative changes in children's learning. Based on a sample of 4 (an extraordinarily small sample), four through six year-old subjects, randomly assigned to either Logo or CAI training sessions, they concluded that mediated training in Logo instruction had a positive effect on children's monitoring behavior during a task presumably difficult for children of their age level. Their analysis also indicated that, over time, the children learned from and responded appropriately to the teacher's cues about what they should do next. This learning of metacognitive strategies allowed the teacher to instruct less and provide more evaluative feedback about the children's performance.

Recent research (Dalbey & Linn, 1985; Dalbey & Linn, 1986; Mayer & Fay, 1987) suggests that children experience a series of cognitive changes as they learn to program in Logo. Mayer and Fay (1987) investigated three specific kinds of changes that develop as children learn Logo. First, children must learn the syntax, precisely what command key words (i.e., Forward 30 or FD 30, Backward 10 or BK 10) are. Then, they must learn to think within the context of Logo programming itself (semantics), that is, they must understand what a command means, i.e., that a "right" turn will always mean the "turtle's" right versus right of the computer screen. And last, they must learn to transfer skills they learn to non-programming contexts. Mayer and Fay concluded that the extent to which children ultimately are able to transfer programming skills to other contexts provides evidence of learning Logo programming. Watson, Lange, & Brinkley (1989) found that pre-school children showed cognitive changes suggested by Mayer and Fay, and, in fact, demonstrated transfer skills to a turtle robot and miniature village task after five weeks of Logo training. This line of research is particularly noteworthy because it has implications for how parents and schools might facilitate cognitive benefits from Logo programming instruction.

Logo Programming Microworlds: Context for Problem Solving

What appears as conflicting results or mixed findings in the literature on what young children learn with Logo programming, may be related to different definitions for Logo programming, (i.e., Logo in a traditional programming sense versus programming in a "contextual" sense). Some researchers seem to use Logo programming to describe a series of written commands to solve problems or answer simple to complex questions on a computer screen. The problems or questions may elicit varying degrees of comprehension and logical reasoning on the part of the programmer/problem solver.

Numerous studies have shown that children are unable to successfully learn the complexities of fundamental programming (Dalbey and Linn, 1985; Gregg, 1978; Kurland and Pea, 1985; Pea and Kurland, 1984; Perkins, 1985; Webb, 1984), even as old as 13 years of age (Krendl and Lieberman, 1988). Many of these studies were attempting to find evidence that computer programming activities could facilitate children's higher-order thinking skills. The criterion used to confirm learning was the children's ability to transfer what they learned from the computer screen to a non-computer programmming environment.

Another group of researchers (Brinkley and Watson, 1989; Clements and Gullo, 1984; Easton and Watson, 1989; Fay and Mayer, 1987; Howard, Sheets, Ingles, Wheatley-Heckman, and Watson, 1988; Mayer and Fay, 1987; and Watson, Lange, and Brinkley, 1989) have found that young children are able to move around a computer screen to solve age-appropriate problems. A distinction between this group of researchers and the earlier group is that this group focused more on the children's ability to use whatever strategies they could to move about the computer screen to solve problems. In many instances this did not require sophisticated knowledge and understanding of Logo programming syntax and semantics. The other studies seemed to require a much more extensive facility with the programming language per se.

Papert (1980) coined the concept "microworld" to refer to the "mindset" and environment in which children can manipulate a "turtle" cursor to do what they want it to do on a computer screen. This context allows children to control what happens on the computer screen and make calculated decisions about specific problems. An abbreviated number of programming commands need to be memorized in order to move and turn the turtle about the screen. But this does not necessarily require a sophisticated understanding of 45 degrees and 90 degrees turns, for example. It is in this sense that the term Logo programming was used in the present study. That is, children were expected to learn a select number of commands well enough to use them to move the cursor about the screen to solve a set of specially designed spatial problems but not to write programs for the sake of writing programs.

Peer Instruction/Mediation With Logo Programming

Although peer teaching and tutoring is a well documented topic in the literature (Slavin, 1978), peer instruction or tutoring with Logo programming is, however, a much less researched area. Recent studies (Emihovich, in press; Jewson & Pea, 1982; Shade, Nida, Lipinsky & Watson,

1986) suggest that children can teach each other with Logo programming and that they often do work on computers cooperatively. Shade et al. (1986) conducted a study with preschoolers and found that they almost always worked on the computer in pairs or triad and demonstrated more helping behaviors as they became experienced. These researchers also noted that the children showed more "assisting" behaviors when an "interactive adult teacher" was present than when not.

In a previously cited study with 4, 4-6 year-olds, Emihovich (in press) examined how young children collaborated with each other, using either Logo or CAI, to develop such metacognitive skills as comprehension and self-monitoring. She found that Logo did have a positive effect on the children's development of the metacognitive skills. She then conducted detailed analyses of the peer interaction that took place during the experiment and found that the children engaged in limited cooperative behaviors without adult supervision. She concluded that the children may have been too young to realistically collaborate with each other in programming activities. But, when given the opportunities to practice giving others help in a structured situation, the children began to develop such helping skills. Possibly, the children in the Emihovich study were either too young or did not understand the nature of the programming tasks well enough to engage in more assisting or teaching behaviors.

Berlinger and Casanova (1988) conducted a study to examine the effects of reduced class size, increased instructional time, computer-assisted instruction, and peer or cross-age tutoring on student learning and found tutoring to have the greatest effect. Of interest was the question of what features or elements of tutoring were effective. Further specificity about the nature of the tutoring process would have helped define the context and parameters of the learning outcomes.

Wood, Bruner, and Ross (1976) suggest that the role of a "tutor" in problem solving is characterized by a "kind of 'scaffolding' process that enables a child or novice to solve a problem, carry out a task, or achieve a goal which would be beyond his unassisted efforts" (p. 90). They argue that the scaffolding process allows the learner to perform at his or her level of competence while the teacher "controls" what aspects of the task are available for consideration. More research designed to test the nature, process, and learning outcomes of peer teaching in a Logo context is clearly warranted.

Theoretical Framework and Model

The theoretical basis for the present research is, largely, information-processing theory of a "cognitive structuralist", Bruner (Bruner & Kennedy, 1966) type. This theoretical approach encompasses some key notions espoused by other cognitive psychologists such as Piaget and Vygotsky. Relevant premises of Bruner's theory include the following central points:

1. Biological dispositions and cultural support determine children's representational systems and this suggests that cognitive development progresses as much from the outside in as from the inside out (Bruner & Kennedy, 1966).
2. Language is the most important representational system to which young children are exposed and this allows them to go beyond iconic representations to logical reasoning, which characterizes Piaget's concrete and formal operations stages (Bruner, 1964).
3. "Formal schooling provides the cultural support to help children make the transition to abstract logical reasoning, for it is in schools that words are systematically and regularly used without their referents" (Greenfield & Bruner, 1966, p. 389).

This theoretical framework implies a very crucial role for the social context of learning. It further implies that the early school environment, with proper tools, could significantly influence children's thinking form (structure) and mode (process).

In addition to Bruner's information-processing theory, several constructs and ideas are borrowed from Papert (1980), Siegel (1978), Vygotsky (1978), and Emihovich and Miller (1987). First, the syntonic learning construct is borrowed from Papert. Syntonic learning refers to learning which is congruent with the individual's sense of what is important in the world. Stated differently, a child will grasp ideas and things which seem relevant and meaningful in his or her life situation. As a child makes sense of various subjects, it is integrated and can then become a part of the child's "sense of life". Papert carefully described how children achieved little understanding of "school math" the way mathematics currently is taught, often quite disjointed and seemingly irrelevant to the learner's "sense of life". If mathematics were taught so that children could first visualize and/or conceptualize its meaning and relevance to life, children might enjoy mathematics and perform better than they are reported to perform.

Papert suggests that learning that is consistent with one's "sense of life" is based on principles of continuity, power (child's), and cultural resonance (learning has meaning relative to the larger social environment). The study reported herein created a social context designed to promote young children's incorporation of Logo programming skills and problem solving into their "sense of life". The computer served as the "cultural tool" with which children thought. The "turtle" became a thinking object which allowed the children to concretize and externalize their thoughts. Children who had difficulty expressing their ideas verbally were able to manipulate the "turtle" to explore and create solutions to spatial problems.

The spatial constructs; objects (landmarks), relationships between objects (routes), and frames of reference are borrowed from spatial development theory (Siegel, 1978). In this study, children were asked to solve certain spatial problems (Watson, Lange & Brinkley, in prep.) within microworlds, a concept described by Papert (1980). The child used the "turtle" to get from one object (landmark) to another, via a direct or indirect route. The child also moved the "turtle" in a Euclidean frame of reference (right/left, up/down, top/bottom, front/back, etc.) regarding the "turtle", computer screen or self. The landmarks were designed to be up-right on the computer screen as they are in the real world. The child sometimes had to restructure a task by making a mental rotation to solve the problems.

Precisely how do children develop the cognitive skills necessary to perform certain tasks is a relevant question. Some literature (Emihovich & Miller, 1986, 1987; Vygotsky, 1978; Wertsch, 1979) suggests that cognitive skills such as problem solving and reasoning are developed primarily from social interactions with adults or more capable peers. A major Vygotskian (1978) premise is that "higher-order" psychological processes are acquired as a child internalizes communication about interactions between her/himself and an adult or a more capable peer.

A child learns from an adult directive but does not necessarily understand the directive when she/he behaves appropriately. That is, a child goes through a "zone of proximal development" (Vygotsky, 1978) or several points whereby an adult gives instructions at different levels of difficulty and may suggest appropriate behavioral responses-- "other-regulation" (Vygotsky, 1978; Wertsch, 1979). The child may respond appropriately without fully understanding the instructions, but given sufficient experience in adult-child interaction relative to the task, performance may eventually result from the child's internalization of the appropriate response-- "self-regulation" (Vygotsky, 1978; Wertsch, 1979).

A child's ability to engage in a cognitive process and successfully complete a task without adult instruction or mediation is not all that matters. Wertsch (1979) points out that the "type" of adult assistance is important to determine how a child makes the transition from "other-regulation" to "self-regulation".

Piaget stated that given the proper social environment, children are capable of performing only cognitive tasks that are developmentally appropriate (Flavell, 1985). He proposed that children develop through four major cognitive stages: sensorimotor (birth to 2 years), preoperational (2-7 years), concrete operation (7-11 years), and formal operations (11 years and older). Progression through these stages may vary by time but not by order and each stage is characterized by one or more cognitive-developmental challenges. Spatial problem solving ability as a cognitive-developmental challenge might be expected to emerge in some children as early as the preoperational stage. The ability of young children to teach spatial problem solving skills to other children is thought to be questionable.

The experimenter theorized that tutors selected from the concrete operations and formal operations stages would exhibit teaching behaviors congruent with the cognitive-developmental capabilities espoused by Piaget. That is, tutors selected from the concrete operations stage was expected to focus on concrete aspects ofthe training. For example, the younger tutors may have been expected to offer more manual assistance, use their bodies to illustrate points, or give more concrete directions as they offered assistance than the college age tutors. In contrast, the college age students may have been expected to ask more questions of the subjects to facilitate their thinking about actions being taken. On the theoretical basis that the college age tutors were expected to have developed a higher level thinking ability, it was expected that they may have used their own reasoning and problem solving skills as examples for the younger children.

The nature and significance of peer instruction designed to develop spatial problem solving skills in a computer environment was the focus of this study. The primary purpose was to examine the learning responses of young children who are taught certain problem solving skills in a Logo environment by same-age peers, near same-age peers, or college students. A secondary purpose was to examine and describe differences in the "teaching" behaviors exhibited by the trained "tutors" in the three age categories: (a) same-age (6-8 years); near same-age (9-12 years), and college students (18-21 years).

CHAPTER III

METHOD

Description of Subjects

A total of 71 people (48, 6-8 years old; 12, 9-12 years old; 11, 18-21 years old) began participation in this study. Thirty-six were selected as subjects and 35 were designated as tutors with each receiving or presenting a part of the treatment condition. All of the subjects and tutors (with the exception of the college age tutors) were enrolled in a summer enrichment program located at an elementary school in a southeastern urban community. This summer enrichment program was a version of an after school enrichment program housed in a local public elementary school which was operated during the regular school year. The college age students were recruited from an area four year, comprehensive, senior college and from an area university.

Letters (see Appendix A) which briefly described the proposed study and also requested parental consent for student participation were sent to parents of all students enrolled in the summer enrichment program on the first day of the program per the request of the Program Coordinator. Also, letters (see Appendix B) were sent to the college students to solicit their voluntary participation.

This selection process limits the degree to which the results might be generalized to a larger population.

Because the sample, through self-selection, may or may not have been representative of the population to which results could be applied, one must exercise caution in the interpretation and generalizability of the findings.

The summer enrichment program was divided into three, 3-weeks sessions. Some of the children were enrolled in multiple sessions while others were enrolled for only one session. As enrollees in the summer enrichment program, the participants were exposed to several structured activities for five days per week from 7:30 am to 6:00 pm. The activities included arts and crafts, gymnastics, swimming, movies, field trips, and other events. This research project became a structured activity for voluntary participants, four days per week, Mondays - Thursdays, 9:00 - 12:00 noon.

The 6-12 years old students came from 10 area elementary schools and two junior high schools and were all a part of a local public school system. Of the original group of participants, 28 pairs participated in the study throughout its duration and provided the data ultimately included in the analyses.

Most of the subjects and tutors who dropped out, did so because of summer vacation schedules. That is, they did not attend consistently the first two sessions (6 weeks) of the summer enrichment program during the time this study was underway. Three subjects withdrew because they did not wish to participate.

Of the 28 subjects who fully participated in this study, 10 were 6 years old, 11 were 7 years old, and 7 were 8 years old. The mean age was 6.89 years. The grade distribution was as follows: (a) nine were in the first grade; (b) 11 were in second grade; and (c) eight were in third grade. In terms of gender and race distribution, there were 16 females, 12 males, four blacks and 24 whites.

Finally, approximately 71% of the subjects had one or more computers in the home, 82% had prior computer experience either at home or at school and nearly 54% had prior experience using a Logo program. In terms of generalizability of findings, these factors also must be taken into account. It may not be appropriate to expect children who have not had comparable exposure to computers and Logo to perform similarly.

Variables of Interest

Independent Variable. The independent variable was the tutors age category and three categories were investigated: (a) same-age peers (6-8 years); (b) near same-age peers (9-12 years); and (c) college age (18-21 years). Once subjects were randomly assigned to a tutor, the pairs worked together throughout the study.

Dependent Variables. The dependent variables in this study were: (a) time to complete a task - the time from which a subject began to work on a specific spatial problem to the time he/she stopped working on that problem during a particular session; (b) number of errors - the number of incorrect actions taken to complete a specific task (problem); (c) number of small (i.e., Forward 10 or FD 10) turtle steps taken; (d) number of large (i.e., Forward 30 or FD 30) turtle steps taken; (e) number of small (45 degrees) angles, i.e., turns selected; and (f) number of large (90 degrees) angles, i. e., turns selected. Previous research (Brinkley & Watson, 1989; Fay & Mayer, 1987; Mayer & Fay, 1987; Watson et al., 1989) showed that these dependent variables were used frequently to assess children's cognitive skills in a Logo programming context.

Design

A mixed, posttest-only repeated measures design was used in this research. The subjects were assigned a tutor randomly and tested repeatedly over a three week period. All of the children enrolled in the summer enrichment program were invited to participate in this research. Because this was an intact group, the experimenter had to address several threats to internal validity through random assignment to treatment groups. This procedure statistically ensured group equivalence (Borg and Gall, 1979).

The original intent was to include all of the voluntary participants but randomly select 30 subjects for inclusion in the analyses. A mortality problem precluded inclusion of 30 subjects because only 28 subjects participated in 12 planned treatment sessions.

After random assignment to one of the three treatment groups which was accomplished by pairing the 6-8 year old subjects with a tutor from the same-age category, near same-age category or college age category, all subjects were given instruction and tutoring concerning the spatial problem solving tasks they were expected to master. The tutoring and problem solving training tasks were observed for 12, 30-minutes sessions over a three week period.

For each of three sets of problem solving tasks, there were 10 "training" problems and 4 "test" problems (see Appendix C). Thus, the subjects had four sets of scores on all dependent measures for which the experimenter calculated an average score per dependent measure.

Experimental Context

The experiment was conducted in a computer laboratory in a public elementary school. There were 15 Apple IIe computers in the room. Two computers were located on each of eight tables except for one which was separated by an isle. Each subject sat in front of a computer and also faced a chalk board. Another chair was situated next to the subject for the tutor.

A RCA video camera, used for video data collection, was placed on a tripod which remained stationary near the right wall midway the room as one would face the chalk board. The camera was focused on the two seats arranged directly in front of the nearest monitor. All equipment was turned on prior to the subjects' entry into the laboratory. Only one video camera was used to minimize intrusive measures, which helped the subjects concentrate on their computer interactions rather than attend to the video taping equipment and procedures.

The software used in this study was "Apple Logo II", (Logo Computer Systems Inc., 1984). This program also was used in the Watson, Lange & Brinkley (1989) research and was deemed to be suitable for young children. The Apple Logo II program allowed one to save procedures in memory.

Procedures

This was a two-part study where Part I involved the experimenter training the tutors and Part II involved the treatment under investigation, cross-age tutoring by same-age, near same-age, and college age students. For each part of this study, training was divided into three stages: (a) Stage I - Training in Logo Positioning Commands; (b) Stage

II - Training in Direct Route Strategies; and (c) Stage III - Training in Indirect Route Strategies (see Appendix D). Part I was conducted during the first three weeks (Session 1) of the summer enrichment program and Part II was conducted during the second three weeks (Session 2).

Part I. The 6-8 years old (same-age) and 9-12 years old (near same-age) children randomly selected to serve as tutors were instructed by their classroom teachers, following a schedule provided by the experimenter. Up to 7 children attended one of five training sessions per day for no more than 4 days per week. Each session lasted 30 minutes. The college age students were provided training at their college site in order to minimize inconvenience and reduce costs.

Instructions to Tutors

At the first training session, the experimenter gave introductory instructions regarding specific use of the microcomputer, software, and general rules to follow in the laboratory. Basic instructions on how to turn the power on and off, how to insert a diskette, and how to get help were provided. The potential tutors were reasonably familiar with these instructions since the experimenter had taken each tutor to the laboratory prior to the first official training session.

Earlier visits to the laboratory were made by the tutors during the first two days of the summer program when parental consent was being solicited. The purpose of these visits was to demonstrate the daily program structure, to allow the tutors to become familiar with what was in the laboratory, and to let them play with some of the EZ Logo programs which were made available. EZ Logo programs were used because of their simplicity, visual appeal, skill building nature, and ability to stimulate interest. The prospective tutors overwhelmingly chose one of two programs; (a) a program involving traveling through a maze which required spatial acuity; and (b) a program called Number Munchers which required speed and accuracy. The skills used with the EZ Logo programs were of the same skill type required for the spatial problems used in this research.

Rules and expectations were defined during the first few sessions and prospective tutors were told that they had a very important role in the research. The experimenter told the prospective tutors that each one of them would be responsible for teaching one 6-8 year old how to draw some interesting designs on the computer. The experimenter added that the prospective tutors would use a tool called a "turtle" to draw whatever they needed to draw on the computer screen.

The experimenter then explained that there were three stages to the study. Next, the experimenter gave specific instructions about Stage I, the positioning commands training. Prospective tutors were told that they were expected to learn 14 positioning commands needed to tell the computer what to do, all of which would be used throughout the study.

During the first week of training the experimenter trained 41 students (17, 6-8 years; 14, 9-12 years; and 10 college students) to use 14 Logo positioning commands. The commands taught were as follows:

1. Show Turtle - ST (Makes turtle appear)
2. Hide Turtle _ HT (Makes turtle invisible)
3. Forward 10 - FD 10 (Small step forward)
4. Forward 30 - FD 30 (Large step forward)
5. Backward 10 - BK 10 (Small step backward)
6. Backward 30 - BK 30 (Large step backward)
7. Right Turn 45 - RT 45 (Small turn to right)
8. Right Turn 90 - RT 90 (Large turn to right)
9. Left Turn 45 - LT 45 (Small turn to left)
10. Left Turn 90 - Lt 90 (Large turn to left)
11. ClearScreen - CS (Clears screen except for turtle)
12. Pen Up - PU (Lifts turtle)
13. Pen Down - PD (Puts turtle down)

14. Pen Erase - PE (Turtle becomes an eraser instead of a drawing tool)

The experimenter explained that the positioning commands were always in reference to the elongated point of the turtle. For example, a Right Turn 90 or RT 90 would always refer to a 90 degrees turn from whatever direction the turtle was pointing at the time that the specific command was properly executed.

The positioning commands were written on the board with diagrams for further clarification and future reference. Both tutors and subjects, therefore, had visible access via blackboard diagrams to the positioning commands throughout the research. Despite the accessibility of the commands, subjects needed to have an understanding of the proper order in which a string of commands needed to be entered into the computer to draw a particular diagram. Such skills were not always intuitive.

Transparencies of specially designed spatial problems (Howard et. al.,1988; Myrick et. al., 1988) that were used in previous research (see Appendix D) with pre-school children were selected for use with the subjects in this study. The tutors were asked to place the transparency over the computer screen and move the turtle cursor around the screen to draw a replica of the spatial design. This task required that the tutor move the turtle in one direction or another to get from Point A to Point B. The overall goal of the problem solving exercises was to facilitate a learner's mastery of the multiple skills needed to successfully complete a spatial problem (draw a spatial design). Inherent in this process was the idea of promoting efficiency and proficiency.

Tutors were expected to learn how to move the turtle from a starting point to a goal point as quickly and as accurately as possible. While there was no predetermined "one right path", several alternatives produced various levels of efficiency and proficiency.

Ten training problems were administered and the tutors received assistance from the experimenter on request. Each stage of training problems was followed by four "test" problems. The tutors were expected to perform the "test" problems without assistance. Successful completion of three out of four test problems was considered evidence of skill mastery for that stage.

After mastery of Stage I, the tutors proceeded to Stage II and Stage III training problems and "tests", respectively. As was expected, the children performed at different rates of speed and with varying degrees of accuracy.

Thirty-six prospective tutors successfully completed the training (i e., 75% of "test" problems) and were prepared to serve as actual tutors. This training lasted 12 sessions for the slowest prospective students. The college students were able to demonstrate competence in one or two sessions. The tutors were informed that they were then prepared to be paired with a 6-8 year old subject to begin teaching what they had learned. This was the end of the tutors training and the end of the first session of the summer enrichment program.

Part II. The first day of the second session of the summer enrichment program was the first day of the experimental treatment. The tutors and subjects were randomly paired from a list of all participants. The experimenter designed the treatment schedule so that no more than six pairs attended the laboratory during any one session. This was done to allow the participants ample space to work without major distractions. This also provided reasonable opportunity for the experimenter to monitor progress, assist individual pairs as needed, and properly prepare for each session.

Instructions to Subjects and Tutors

Again, the experimenter gave introductory instructions about the use of the hardware, software and otherwise general use of the computer laboratory. Following a brief presentation about purpose of the study, the experimenter reminded the subjects that their teacher would be either a person their own age, a person near their age or a college student. The tutors also were reminded that they were expected to keep scores on their tutees performance, that is, record the commands used, number of errors, time to complete a problem, and whether the tutor provided verbal or manipulative help (see Score Sheet, Appendix E).

Finally, the tutors and subjects were reminded that there would be videotaping of each session and pairs would be randomly seated at the computer in front of the camera. They were informed that only five minutes of each session would be taped and that the experimenter would try to determine if tutors from the three age groups taught their group differently. The tutors were given a transparency of Card 5a (see Appendix D), the first training problem, to place over their computer screen. They then began to tutor their subject on making the design replica. As was the case with training the tutors, the subjects were provided 10 training problems to help them master this first stage. At the beginning Stage I, the experimenter observed each subject's drawings to make sure that there was consistency in what was considered a reasonable replica of the drawings on the transparency.

After successful completion of Stage I training problems the tutors presented the four "test" problems which they were expected to do without assistance. Successful completion of three out of four of the test problems was the criterion for moving on to the two subsequent stages.

Data Collection

As previously stated, this study lasted six weeks, but data were collected only during weeks 4-6 when the trained tutors provided instruction to the subjects. The subjects were scheduled for computer interaction for 30 minutes sessions four times per week: Monday - Thursday between 9:00 am and 12:00 noon. The sessions were typically scheduled the same time every week.

While the tutors were responsible for recording the subjects' performance on the dependent measures using a Score Sheet, the experimenter was responsible for making sure that each tutor/subject pair had a Score Sheet, pencil, and stop watch. Because recording was a major challenge and responsibility for the tutors, it required careful planning and structuring by the experimenter.

Prior to the tutors and subjects arrival, the experimenter turned on the computers and "booted up" the Apple Logo II program in all the computers. Appropriate transparencies were placed over the computer screens and pencils and stop watches were placed at each seating arrangement. Approximately 10 minutes were needed between sessions to take up the Score Sheets and transparencies, and place new ones at the computers for the next group of subjects.

Videotaping

A technical assistant made sure that the video equipment was properly working. Also, he assumed responsibility for systematic taping of the sessions. The equipment was stationed in a permanent location throughout the study. The technical assistant taped the first five minutes of every 30 minutes session, four days per week for three weeks. This brought the total taped time to 240 minutes or 4 hours.

Subjects were randomly assigned to computers each day and each session of treatment; therefore, the videotapes reflected a cross-section of the participating pairs over the 12 sessions of the actual treatment condition. A code sheet (see Appendix F) was used to record the experimenter's observations of specific types of behaviors exhibited by the tutors during their teaching and tutoring sessions.

The experimenter was interested in differences in the teaching behaviors found between the tutors in the three age categories which might relate to, if not explain, any significant differences in the subjects' learning outcomes.

These observations were intended to add descriptive and qualitative information to the available quantitative data.

CHAPTER IV

RESULTS

Analysis of Data

The original intent of this study was to analyze the data for each stage of Logo training as separate analyses. Since there were too few subjects, five and three respectively, who completed Stages II and III, the following statistical analyses were performed to test the hypotheses only for Stage I.

Because there were four test cards at the end of each stage of training, an average score was calculated for each dependent measure. An Analysis of Variance (ANOVA) procedure (SAS Manual, 1982) was used to determine if there were any significant differences between subjects' performance on the dependent measures recorded as average scores (i.e., average time to complete a spatial problem, average number of errors, average number of small turtle steps selected, etc.). Scheffe's Multiple Comparison test (Tabachnick & Fidell, 1983) was used to ascertain which groups accounted for any statistically significant differences revealed by the ANOVA procedure. Pearson Correlations were performed to determine if there was a significant relationship between the subjects' average time to complete a task and the average number of errors made.

Data were analyzed using the Statistical Analysis System (SAS) (SAS Manual, 1982).

Frequency tabulations were compiled on the videotaped data to provide additional information regarding types of teaching behaviors exhibited by the tutors. The specific teaching behaviors observed and recorded for descriptive purposes were previously used in Logo research by Emihovich (In press) and were as follows:

(a) Elicit: An elicit exchange type is headed by an elicitation or question functioning to request a language response. An example of this type might be, What did you just do?

(b) Direct: A direct exchange type is headed by an imperative functioning to request an action, nonlanguage response. An example of this type might be, No, wait. Don't press m, press return.

(c) Inform: An inform exchange type is headed by utterances designed to be informative, to impart information to listeners. An example of this type might be, Now think about the face of a clock. An RT90 would look like the hour hand set at 3:00 if and only if the turtle is pointing toward the top of the screen.

(d) Initiate: An initiate exchange is headed by utterances functioning to get an action underway. An example of this type might be, Press return and see what happens.

(e) Reinitiate: A reinitiate exchange type is headed by utterances designed to re-establish the line of discourse which a teacher or student feels may have gotten "off the track." An example of this type might be, When you said Pen-Up did you mean point the turtle toward the top of the screen? (Pen-Up is the command to prevent the turtle from drawing lines as it moves).

(f) Check: A check exchange type is headed by an actual question seeking unknown information, such as Are you finished typing now?

(g) Repeat: A repeat exchange type is headed by an utterance designed to elicit again an utterance made by someone, such as What did you say?

As was stated in the previous section, it was expected that the subjects in this study would be able to learn 14 Logo positioning commands in the first week (four 30 minutes sessions) of training. It was then expected that the subjects would progress to Stage II to solve the specially designed spatial problems that required moving the turtle from a particular location (turtle home) to a target location (turtle school) using a "direct route strategy". Stage II was expected to last one week or four 30 minutes sessions. After successful mastery of the direct route strategy problems, subjects were expected then to solve the specially designed indirect route strategy problems in a third week of four 30 minutes sessions.

Results revealed that 28 subjects remained for the three consecutive weeks of 12, 30-minutes training sessions. Of these 28 subjects, 100% completed Stage I, nearly 18% (5 subjects) completed Stage II, and 11% (3 subjects) completed Stage III.

There were too few subjects who completed Stages II and III to conduct statistical analyses for those stages. The SAS GLM procedure (SAS Manual, 1982) was used to analyze data from Stage I. This procedure was thought to be the most appropriate statistical tool due to the unequal number of subjects in each treatment (tutors age category) group. The alternative SAS ANOVA procedure is designed for cases with equal numbers per treatment group. The alpha level was set at .10 because of the small sample size and the short duration of treatment.

<u>Hypothesis (Ho) 1</u>

There will be no significant differences in the learners' time to complete a task across the three tutors age categories. Results of a one-way Analysis of Variance procedure indicate that at the .10 level of significance there was not sufficient evidence to reject the null hypothesis since $F(2,22) = 1.04$ and $p < .37$ (see Table 1a.).

Table 1a

Analysis of Variance Summary for the Subjects' Time to Complete a Task by Tutors Age Category

Source	DF	MS	F Value
Tutors' Age Category	2	2.956	1.04
Error	22	2.840	
Total	24		

p = .37

Table 1b

Means for Subjects' Time to Complete a Task by Tutors Age Category

Tutor's Age Category	N	Mean	SD
Same-Age	10	5.071	2.159
Near Same-Age	9	5.361	1.781
College Age	9	4.250	1.068

Hypothesis (Ho) 2

There will be no significant differences in the learners number of errors across the three tutors age categories. Again, results of a one-way ANOVA procedure indicated that there was insufficient evidence to reject the null hypothesis at the .10 level of significance because F (2,22) = .09 and p = .919 (see Table 2a.).

Table 2a

Analysis of Variance Summary for the Number of Subjects' Errors by Tutors Age Category

Source	DF	MS	F Value
Tutors' Age Category	2	0.077	0.09
Error	22	0.901	
Total	24		

p = .919

Table 2b

Means for Number of Subjects' Errors by Tutors Age Category

Tutor's Age Category	N	Mean	SD
Same-Age	10	1.464	1.342
Near Same-Age	9	1.472	0.922
College Age	9	1.222	1.302

Hypothesis (Ho) 3

There will be no significant relationships found between the learners time to complete a task and the number of errors made. A Pearson Correlation procedure revealed that for subjects tutored by same-age peers, there was a low positive correlation (r=.20) between the average amount of time in minutes to complete a task and the average number of errors made. For the subjects tutored by near same-age peers, there was a moderately positive correlation (r=.49) between the same two variables. But for the subjects tutored by the college age students, there was a strong positive correlation ($r=.78$) between the above mentioned dependent variables.

Hypothesis (Ho) 4a

There will be no significant differences found in the learners use (number) of small turtle steps selected across the three tutors age categories. The one-way ANOVA procedure revealed that there was sufficient evidence to reject the null hypothesis at the .10 level of significance since $F(2,22) = 4.53$ and $p = .02$ (see Table 3a.). This finding was not surprising since the use of small turtle steps could reflect efficient use of commands if used to draw a more precise replica of a design to avoid over exaggerating with large steps. That is, as a subject approached a target point and one or more large steps would exceed the target, then small steps might be more appropriate and efficient to complete the replica.

Table 3a

Analysis of Variance Summary of the Number of Small Turtle Steps Selected by Tutors Age Category

Source	DF	MS	F Value
Tutors' Age Category	2	2.941	4.53
Error	22	0.649	
Total	24		

p = .023

Because a significant difference was found between the groups on this dependent variable, a Scheffe multiple comparison test (Tabachnik & Fidell, 1983) was performed to determine between what groups the significant differences were found. The results of the Scheffe test revealed that at the .05 alpha level a significant difference was found between the subjects tutored by same-age peers and those subjects tutored by college age students. The mean for the same-age tutors was 1.250 and the mean for the college age students was 2.472 (see Table 3b.). The subjects tutored by the college age tutors used the small step command more frequently than did the subjects tutored by the same-age peers, as was expected. This finding is consistent with previous research (Brinkley & watson, 1989; Watson et. al., 1989) which revealed that young children have a preservation for big steps.

Table 3b

Means for Number of Small Turtle Steps Selected by Tutors Age Category

Tutor's Age Category	N	Mean	SD
Same-Age	10	1.250	0.853
Near Same-Age	9	1.944	0.982
College Age	9	2.472	0.522

Hypothesis (Ho) 4b

There will be no significant differences found in the learners use (number) of large turtle steps selected across the three tutors age categories. Results of a one-way ANOVA procedure indicated that there was not sufficient evidence to reject this null hypothesis at the .10 level of significance, since $F(2,22)=.04$ and $p = .96$ (see Table 4a.).

Table 4a

Analysis of Variance Summary for the Number of Large Turtle Steps Selected By Tutors Age Category

Source	DF	MS	F Value
Tutors' Age Category	2	0.184	0.04
Error	22	4.625	
Total	24		

$p = .961$

Table 4b

Means for Subjects' Number of Large Turtle Steps Selected by Tutors Age Category

Tutor's Age Category	N	Mean	SD
Same-Age	10	9.857	2.184
Near Same-Age	9	10.139	2.332
College Age	9	9.917	1.924

Hypothesis (Ho) 5a

There will be no significant differences found in the learners use (number) of small angles (45 degrees) selected across the three tutors age categories. Again, results of a one-way ANOVA procedure yielded an $F(2,22)=.03$ and $p= .97$ which did not provide enough evidence to reject the null hypothesis (see Table 5a.).

Table 5a

Analysis of Variance Summary for the Number of Small Angles (45 degrees) Selected by Tutors Age Category

Source	DF	MS	F Value
Tutors' Age Category	2	0.049	0.03
Error	22	1.550	
Total	24		

$p = .969$

Table 5b

Means for Subjects' Number of Small Angles Selected by Tutors Age Category

Tutor's Age Category	N	Mean	SD
Same-Age	10	1.125	1.018
Near Same-Age	9	1.180	0.956
College Age	9	1.278	1.603

Hypothesis (Ho) 5b

There will be no significant differences found in the learners use (number) of large angles (90 degrees) selected across the three tutors age categories. The one-way ANOVA procedure revealed an F(2,22)=.17 and p= ..843 which, at a .10 level of significance, did not provide sufficient evidence to reject the null hypothesis (see Table 6a.).

Table 6a

Analysis of Variance Summary for the Number of Large Angles (90 degrees) Selected by Tutors Age Category

Source	DF	MS	F Value
Tutors' Age Category	2	0.115	0.17
Error	22	0.669	
Total	24		

p = .843

Table 6b

Means for Subjects' Number of Large Angles

Selected by Tutors Age Category

Tutor's Age Category	N	Mean	SD
Same-Age	10	2.107	0.663
Near Same-Age	9	2.347	0.810
College Age	9	2.264	0.924

Description of Tutors Teaching Behaviors

The experimenter viewed, coded and tabulated the frequency of seven specified teaching behaviors found on the video tapes. After viewing the tapes, it was necessary to exclude any observations of subjects whose quantitative data were not included in the analyses. The following frequency tabulations reflect observations systematically recorded for subjects whose quantitative data were previously reported. The experimenter used as a baseline the minimum amount of time that any one tutor category was represented when all categories were totaled for a given week. For example, during Week I, five subjects tutored by same-age peers were taped for five minutes each, eight subjects tutored by near same-age peers for the same amount of time, and only three subjects tutored by college age students were taped for five minutes each. Therefore, the baseline for Week I was three five-minute sessions or 15 minutes. The baseline for Week III was 20 minutes.

Table 7

Frequency of Teaching Behaviors by Tutors Age Category: Week I

Type Behavior	Same-Age	Near Same-Age	College-Age
Elicit	0	5	1
Direct	4	3	2
Inform	0	4	8
Initiate	12	12	10
Re-Initiate	0	0	0
Check	2	2	3
Repeat	0	0	0

Table 8

Frequency of Teaching Behaviors by Tutors Age Category: Week III

Type Behavior	Same-Age	Near Same-Age	College-Age
Elicit	0	2	9
Direct	3	3	4
Inform	0	3	6
Initiate	9	19	15
Re-Initiate	0	0	0
Check	0	2	0
Repeat	0	0	0

CHAPTER V

DISCUSSION

Previous Findings

Earlier research (Shade, 1986) indicates that preschoolers as young as three years of age are able to learn to use Logo. Following training in Logo, even some five and six year olds are able to solve spatial problems (Watson, et. al.) and improve mathematics achievement scores (Emihovich, in press) . In the prior research concerning children using Logo to enhance cognitive or mathematical skills, adults were the primary teachers. The major distinction between this research and the present study is the primacy given to the role of same-age peers, near same-age peers, and college age students as teachers. Another major distinction found in the present study is the responsibility that was placed on the cross-age tutors to serve as data collectors. This was an especially demanding task for the tutors, because relatively new skills were required. In many instances the experimenter observed that tutors became more concerned about their recording responsibility to the exclusion of tutoring.

Significance of Present Study

This research was important because it included components of earlier research (Dalbey & Linn, 1985; Gregg, 1978; Perkins, 1985; Kurland & Pea, 1985; Pea & Kurland,

1984) which showed that children are unable to understand and use Logo programming as a problem solving tool and components of more recent research (Brinkley & Watson, 1989; Easton & Watson, 1989; Fay & Mayer, 1987; Mayer & Fay, 1987; Watson & Busch, 1989; Watson et. al., 1989) which showed that young children can solve problems using abbreviated Logo programming commands. Specifically, this research required that the subjects successfully replicate four "test" problems after each stage of Logo training without assistance from a tutor. A child's ability to successfully complete at least three of the four "test" cards without assistance served as evidence of learning. This aspect of the present study was similar to earlier studies that showed children unable to understand Logo programming as a function of poor task performance. Previously, task performance was judged in terms of a child's ability to transfer problem solving skills used on a computer screen to a non-programming context that was often quite different in nature. Emphasis was often placed on the child's ability to understand more sophisticated Logo programming language (syntax) and meaning (semantics) (Fay & Mayer, 1987) rather than focused on problem solving in the Logo context.

Major Findings

Contrary to earlier findings, the children in the present study learned to successfully program in three weeks of training or less. And, they learned from same-age peers, near same-age peers, or college age students. This was a major accomplishment for the children and a major contribution to this body of literature. This finding provides additional evidence in support of the Watson and Busch (1989) theory and the Fay and Mayer (1987) model which showed that children are able to solve age-appropriate problems using Logo if they learn an abbreviated set of commands and have enough time to solve the problems. Consistent with the Fay and Mayer study, the children in the present study also experienced some confusion regarding the commands, but they were still able to successfully complete Stage I training. For example, the experimenter observed some children trying to "move" the turtle cursor with a "turn" command, i.e., using a RT 90 to turn the turtle to the right and draw an inch and a half long line. Watson and Busch argue that children first must learn a limited number of basic commands before they are able to move freely about the computer screen to solve problems. The amount of time it takes for children to learn the commands may vary from one situation to another. In the Watson et. al., study the young children were allowed to receive help with their training and test problems. They also were not expected to get a problem "correct" before moving on to another one. It was assumed that the continual practice over time would make up for any deficits resulting from not successfully completing every training or test problem.

In the present study, five children, ages seven and eight (second and third graders), went on to successfully complete training in Stage II, Direct Route Strategies, and three of these five successfully completed Stage III, Indirect Route Strategies during the three weeks session. This result contradicts earlier research (Dalbey & Linn, 1985; Gregg, 1978; Kurland & Pea, 1985; Pea & Kurland, 1984; Perkins, 1985) which showed that children as old as 13 years of age could not learn to program with Logo. Some explanations for why these children were able to successfully complete all three stages include the following: (a) they were older and had mastered the alphabet before this training; (b) They could read and understand written as well as verbal instructions more readily; (c) they were more familiar with the keyboard and knew where to find letters easily; (c) they had prior experience with microcomputers and Logo, specifically; and (d) they understood the syntax and semantics well enough to move along with or without assistance.

For the remaining 23 children, three weeks was ample time to successfully learn 14 positioning commands, complete 10 training problems, and four "test" problems (Stage I). This time frame was predicated on the Watson et. al., (1989) study and their results which suggested that preschoolers were able to finish 24 or more spatial problems, per week. The Watson et. al. findings are inconsistent with the Fay and Mayer (1987) results which revealed that subjects in fourth to eighth grade (average age between 9.5 - 13.6 years) were confused about the "move" (FD 10, BK 30, etc.) and "turn" (RT 90, LT 45, etc.) commands. Unlike the present study where six to eight year olds had 14 commands to learn, the older subjects in the Fay and Mayer study had only six commands to master. By contrast, the preschoolers in the Watson et. al. study successfully completed Stage I, Training in Logo Positioning Commands in four 20 minute sessions.

A major distinction between the Watson et. al. study and the present study is that the preschool children received help on an "as needed" basis with any of their problems. They also were not required to successfully complete a problem before moving on to another problem. That is, after a minimum number of trials a child could move on to another problem. The children in the present study moved on to subsequent problems and stages only after successful completion of the preceding problem. This could explain why the preschoolers successfully solved more problems in a shorter time frame. Overall, when given enough time, the children in the Watson et. al. study, the

Fay and Mayer study, and the present study showed improvement in their knowledge, understanding and application of the Logo commands. Also, if the tutors in the present study were not required to record data as they went along, they may have been more helpful in their teaching role. Consequently, the subjects may have mastered the Logo commands more readily and they may have successfully completed more problems in the specified time frame.

Hypotheses 1, 2 and 3.

Results showed no signicant differences in the subjects' average amount of time taken to complete a problem ($p = .370$) across the tutor age categories. This finding suggests that all of the subjects took, approximately, the same amount of time per problem regardless of the age of their tutors. Likewise, results showed no significant differences in the subjects' number of errors made ($p = .919$) across the tutor age categories. This could mean that either the problems produced no excessive difficulty for the children or any difficulty was equally shared among them. It appears that the children proceeded through the training and test problems in a similar fashion in terms of efficiency and proficiency. This finding was somewhat surprising because it was expected that the subjects tutored by same-age peers would understand less and require significantly more time to successfully complete a problem. This expectation was partly based on previous research (Fay & Mayer, 1987) that showed children to have naive conceptions about Logo syntax and semantics. Similarly, it seems quite common for six-eight year olds to experience confusion about the difference between "right" and "left". They may just as likely experience no knowledge or confusion about angles (45 degrees and 90 degrees). It also was expected that the same-age subjects would make more mistakes as a result of misunderstanding or not understanding instructions.

A Pearson Correlation was performed to assess the relationship between the average time to complete a problem and the number of errors made, by tutor age categories. Since there were less than 10 or fewer subjects in each group for these analyses, it was virtually impossible to interpret these results, (because one extreme score could account for an inflated or deflated correlation) and provide valid explanations.

Hypotheses 4a and 4b.

Results showed that there were significant differences found in the subjects' use of small turtle steps ($p = .023$) when compared by tutor age categories, but no significant differences in the use of large turtle steps ($p = .961$). An evaluation of the means reveal that the same-age subjects seldom used the small turtle steps. They seemed to prefer using large steps even when using a large step meant drawing an inaccurate replica of a design. The subjects tutored by college age tutors seemed to use the small steps to help draw a more accurate replica of a design. In general, all subjects used large steps more frequently than they used small steps regardless of the tutor age category. These findings support similar findings noted in the Brinkley & Watson (1989) and Watson et. al. (1989) studies where preschool children also used large turtle over small turtle steps.

Hypotheses 5a and 5b.

Results showed that there were no significant differences found in the tutors use of small (45 degrees) angles ($p = .969$) nor large (90 degrees) angles ($p = .843$). The children seemed to use mostly large angles or turns, and specifically large right turns (RT 90 command). This might be explained by children's general familiarity with 90 degree angles and turns in their real life experiences (Brinkley & Watson, 1989). This also would be congruent with Papert's (1980) syntonic learning construct.

Young children seemed to use their bodies and pointing behaviors (Brinkley & Watson, 1989; Watson & Busch, 1989; Watson et.al., 1989) at the beginning of the training sessions to help them direct the turtle cursor around the screen. Mayer and Fay's (1987) model and Fay and Mayer's research (1987) provide further evidence that young children exhibit an egocentric conception of space as they relate left and right to their bodies rather than in relation to the turtle. But this behavior changed as they became more familiar with the turtle commands and how to move about the screen. They were increasingly better able to use "other perspectives" (Watson & Busch, 1989).

Subjects unequivocally used more FORWARD moves than BACKWARD moves, more LARGE moves than SMALL moves, more RIGHT turns than LEFT turns, and more LARGE turns than SMALL turns. These findings were evident across the age categories of the tutors. That is, the children seemed to make these selections regardless of the age category of their tutor. These findings also are consistent with prior research findings (Brinkley & Watson, 1989; Easton & Watson, 1989; Watson & Busch, 1989; Watson et. al., 1989) concerning preschool children.

Tutors "Teaching" Behaviors

Analyses of the frequency distributions of the tutors' teaching behaviors revealed that during the first week of training in Logo positioning commands, all subjects were more likely to exhibit the "initiate" type behavior than any of the other types of behaviors examined. As previously stated, this type of behavior was characterized by any utterances made by the tutor to facilitate an action by the subject, such as "Now press CS and see what happens to the turtle."

It was expected that the college age tutors would demonstrate more "elicit" type behaviors to facilitate thinking and learning than would the same-age or near same-age peers. This expectation was predicated on cognitive-developmental theory (Flavell, 1979, 1985) which suggests that persons in the formal operations stage of development are capable of more abstract thinking and reasoning than persons in concrete operations or the pre-operational stage. Therefore, they may have been expected to raise questions that would elicit abstract thinking and reasoning on the part of their subjects.

Similarly, the college students were expected to have a more extended vocabulary that would have allowed them to use more verbal instructions versus manual manipulations to facilitate actions by the subject. Results showed this not to be the case during the first week. But rather, the near same-age tutors were five times as likely to exhibit an "elicit" type echange. Reviews of the videotapes also revealed that during the first week of training the college age tutors were twice as likely to use the "inform" type exhange as the near same-age tutors, while the same-age tutors were not observed using this type exhange at all.

Interestingly, by the third week of training, the college age tutors were nearly ten times as likely to exhibit an "elicit" type exchange, and three times as likely to use an "inform" type exchange as the tutors in either of the other groups. Also, while the near same-age tutors and college age tutors increased their usage of the "initiate" type exchange by the third week, the same-age tutors slightly decreased their use of this type.

One possible explanation for the differences observed in the frequency of the "elicit", "inform", and "initiate" type exchanges may be associated with the younger children's comprehension of the Logo language features (syntax) and semantics and consequently, their ability to articulate or show more "teaching" exchanges. It appeared that the younger the child was, the more likely he or she was to offer manual versus verbal assistance of any type.

It also was quite possible that as time passed, the same-age tutors may have lost some of their interest in tutoring, but not necessarily in helping out in other ways, such as keeping time. Failure to experience a feeling of success in tutoring or learning may have precipitated a decrease in tutor motivation.

CHAPTER VI

CONCLUSIONS

This study empirically addressed an issue which is debated concerning the cognitive benefits of Logo programming for young children. Specifically, it examined whether or not young children were able to learn 14 Logo positioning commands and demonstrate this learning by solving a set of specially designed spatial problems. Much of the controversy concerning the cognitive benefits of teaching young children Logo programming has centered around transfer of skills (Salomon & Perkins, 1987) to non-programming contexts. This study was not designed to assess the ability of young children to transfer what they learn to different contexts but rather to assess if they could understand, remember, and use a string of commands to solve certain microworld problems. Hence, the emphasis in this study was on the mastery of a few commands to solve problems instead of learning commands in order to write programs. Unlike previous research, it also focused on the learning responses of young children who were taught by same-age peers, near same-age peers, and college age students.

Twenty-eight six to eight year old children were trained by cross-age tutors in a study designed to compare differences in their time to complete selected spatial problems, number of errors made, the size of turtle steps selected, and the size of angles or turns chosen. These young children worked on solving microworld problems for 12, 30-minute sessions over a three week period. The tutors were observed to determine what type of "teaching" behaviors characterized their training exchanges.

General Conclusions

Results revealed that all of the subjects learned 14 Logo positioning commands with cross-age tutors. The tutor age category had no effect on the subjects' time to complete the problems, nor on the number of errors made. There was a significant difference in the young children's use of small turtle steps when tutored by same-age peers and by college age students. The children tutored by college age students used more small turtle steps and seemed to do so more efficiently. However, there were no significant differences in the children's use of large turtle steps, small and large angles.

It appeared that all subjects used more FORWARD, RIGHT, and LARGE commands than any others, as expected. This finding was consistent with Brinkley and Watson (1989), Easton and Watson (1989), Fay and Mayer (1987) and Mayer and Fay (1989).

As previously stated, the children learned to problem solve with the cross-age tutors and successfully mastered 14 commands in three weeks (i.e., 12, 30-minute training sessions). It appears that young children were quite capable of learning a limited number of commands to solve problems when the emphasis was on working in a Logo environment versus learning to write programs per se (Watson & Busch, 1989).

Findings also revealed that the frequency of "teaching" type behaviors exhibited by the tutors varied by age category for at least three exchange types, "elicit", "inform", and "initiate." Initially, all tutors frequently used the "initiate" type exchange. The near same-age tutors used the "elicit" type exchange five times as often as did the college age students, which was somewhat unexpected. The college students used the "inform" type twice as often as the near same-age tutors, and the same-age tutors did not use this type at all.

During the third and final week the same-age tutors used fewer of all types of exchanges than they did during the first week. The college age tutors increased their use of "elicit" and "initiate" type exchanges, as might be expected. It appeared that as time passed the young children became less active in tutoring and mostly focused their efforts on recording data. Overall, the subjects seemed to learn very well from the cross-age tutors, despite earlier claims that young children were unable to learn Logo programming from adult teachers.

Due to the sample size, self-selection and voluntary nature of the sampling procedure, one must exercise caution in generalizing the results of this research to other populations. The subjects were largely middle-class children with prior home and school computer experience. Their Logo experience, however, was with EZ Logo which is a very simple version of the Logo II program used in this research study.

Recommendations for Future Research

Because most of the subjects in this research needed approximately three weeks to learn the positioning commands, future research that will allow more time to move through three stages of training is indicated. Additional research is needed to determine what variables significantly influence what young children learn best with Logo programming and what factors most significantly inhibits their learning. If cross-age tutors are used to train, it would be very helpful to have someone else responsible for recording data. In this study it seemed as though teaching and tutoring were inhibited by data collection.

A larger sample size and a probability sampling procedure would greatly enhance the researcher's ability to find significant differences between groups, if and where they exist. Cooperation and support from a public school system to conduct such research during a regular academic year during school hours might greatly reduce some of the limitations encountered in this study.

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Appendix A

Parent Permission Letter and Form

Dear Parent(s):

As a student in the Lansdowne After School Enrichment Program (ASEP) or Summer Enrichment Program, your child may have an opportunity to participate in a microcomputer research project. The primary purpose of this research is to examine the learning outcomes of young children who are taught certain problem solving skills in a computer environment by same-age peers, near same-age peers and college students. This project will further examine differences in the teaching approach used by the "tutors," which may or may not be significantly related to the age of the tutor. Since computers are being used increasingly in all schools today, I believe that students might greatly benefit from peer teaching and problem solving in a computer environment, which may help them in other academic and intellectual activities.

Your child already may have been exposed to Logo (computer language especially designed to be used by young children as well as adults) programs in his/her school or home. Regardless, in this project, each child will be taught 10 Logo positioning commands which will allow him/her to move the "turtle" (cursor) about the computer screen by pressing certain keys on the keyboard. After each child has learned how to move the turtle from one point to another, he/she will be taught to use a string of commands to solve some spatial problems. That is, a child will be taught how to move the turtle from its home station to any point on the computer screen. In some instances a direct route may be taken to move the turtle from one point to another point, but in other cases an indirect route must be taken. The child must try to find the most efficient (quickest and best) route to move the turtle from its home station to a target location.

Fifty (50) children will be randomly selected from the overall pool of children in the summer program. Each child selected for participation will be trained first, then asked to perform certain "test" problems to see how well he/she performs. The sessions will include random videotaping of the interactions between "learners" and "teachers" to determine what the "teachers" may be doing differently, if anything.

This project is expected to take six weeks beginning June 13, 1988. Each child will attend at least three 30 minute sessions per week, but no more than five sessions per week. Your written permission is needed in order for your child to participate in this research project. If you grant permission, you or your child may withdraw your child's participation at any time without any adverse consequences to your child or yourself. You may also request access to the findings of this research.

In addition to your consent for your child to participate in this project, I solicit your permission to have access to the most recent (within the last three years) California Achievement Test or Stanford Achievement Test (whichever is applicable for your child) and Cognitive Ability Test scores available in school records. Individual scores will not be used per se, but will be used collectively only to obtain group statistics for descriptive analyses.

If you have any questions about this project, please feel free to contact me at (704) 364-1057 (home) or (803) 323-2168 (work).

Please complete the attached form and have your child return it to the ASEP Coordinator by June 15. Thank you for your cooperation and support.

Sincerely,

Wilhelmenia I. Rembert

Project Investigator

Please check appropriate statement(s):

_____ I grant permission for my child to participate in this project.

_____ I grant permission for my child's cognitive and achievement test scores (from school records) to be used for group statistics and descriptive analyses only.

_____ I would like a copy of the research results of this study.

_____ I do not grant permission for my child to participate in this project.

____
Name of Student

____
Parent Signature Date

Appendix B

College Student Consent Letter and Form

Dear Student:

I solicit your voluntary participating in a microcomputer research project. The purpose of this research is to examine the learning outcomes of young children who are taught certain problem solving skills in a computer environment by same-age peers, near same-age peers and college students. This project will further explore differences in the teaching behaviors exhibited by the "teachers/tutors," which may or may not be significantly related to the age of the teacher/tutor. Since computers are being used widely and increasingly in most schools today, I believe that students might greatly benefit from Logo training and peer teaching, either or both of which could possibly enhance their problem solving skills in a computer environment. If such is the case, the cognitive benefit of Logo training and/or peer teaching might extend to other academic and intellectual activities.

Your role in the study would be that of a teacher/tutor. But first, I would provide training for you in three stages: (I) Instruction in 10 Logo Positioning Commands; (II) Direct Route Strategy Instruction - how to move the "turtle" (cursor) from its home station (directly) to a target location; and (III) Indirect Route Strategy Instruction - to move the "turtle" from its home station, around one or more barriers, to a target location. You would then be expected to solve some specially designed spatial problems by finding the most efficient (quickest and best) route to move the turtle from its home station to a target location. After you have been properly trained, you will train at least one 6-8 year old child by teaching her/him the same three-stage Logo instruction you received.

The session will include random videotaping of the teacher-learner interactions to determine what, if anything, the teachers in one of three age groups may be doing differently.

This project is expected to take six weeks beginning June 13, 1988. Your written consent is needed for you to participate. If you voluntarily agree to participate, you may feel free to withdraw at any time without any adverse consequences or prejudices against you. You may also request access to the findings of this research.

In addition to your informed consent to participate, I solicit that you provide a copy of your college transcript. Individual test scores or grade point averages will not be used per se, but will be used only to obtain group statistics for descriptive purposes.

If you have any questions about the project, please feel free to contact me at (704) 364-1057 (home) or (803) 323-2168 (work).

Please complete the attached form and return to me by June 10. Thank you for your cooperation and support.

Sincerely,

Wilhelmenia I. Rembert
110-B Kinard
Winthrop College
Rock Hill, SC 29733

I, ________________________________, voluntarily agree to participate in this microcomputer research project.

____
Signature

____
Date

I do/do not want a copy of the research results of this study.

Appendix C

Student/Parent Questionnaire

STUDENT/PARENT QUESTIONNAIRE

LOGO TRAINING AND PEER INSTRUCTION MICROCOMPUTER RESEARCH PROJECT

______________________ Student Name	______________________ Date of Birth
______________________ School	______________________ Grade
______________________ Ethnic/Racial Identify	______________________ Gender (Female/Male)
______________________ Parent Name	______________________ Telephone #
______________________ Street Address	______________________ City/State/Zip

Please circle correct response:

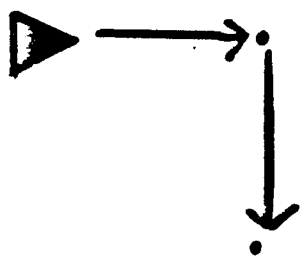
Yes	No	1.	Has the student had experience with a microcomputer?
Yes	No.		a. At school
Yes	No		b. At home
Yes	No	2.	Has the student had experience with an Apple computer?
Yes	No	3.	Has the student had experience with a "Logo" program?
Yes	No	4.	Does the student tend to work on a computer alone?
Yes	No		a. With a parent
Yes	No		b. With a sibling
Yes	No		c. With a peer
Yes	No		d. With a teacher

1 2 3	5. How many computers are available in your home?
Yes No	6. Is the computer owned by the student?
	a. By the parent(s)
	b. By the family
Yes No	7. Are child-computer interactions generally child initiated?
Yes No	a. Parent initiated
Yes No.	b. Teacher initiated
Yes No	c. Seldom initiated by either
Yes No	8. Does the student like to work on computers?
Daily Weekly Monthly Rarely	9. How frequently does the student work on a computer?
0-1 1-3 3+	10. How many years has the student been exposed to computers?
0-1 1-3 3+	a. Apple
0-1 1-3 3+	b. Logo
	a. At home

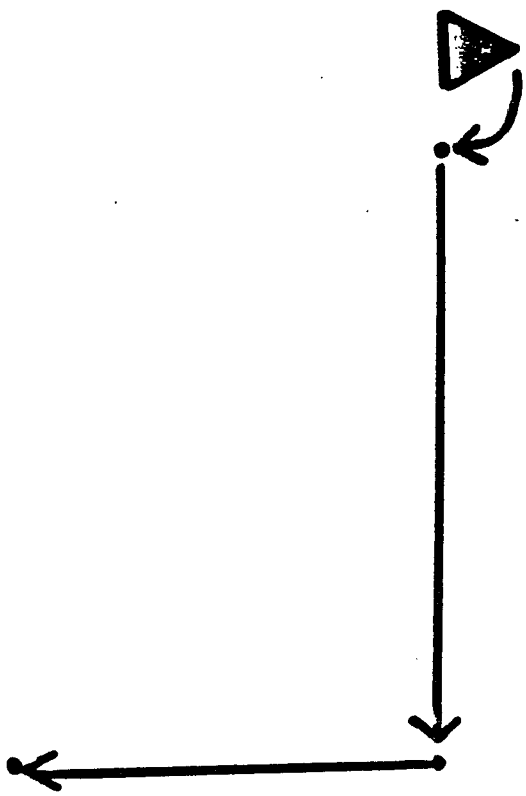
b. At home

Appendix D

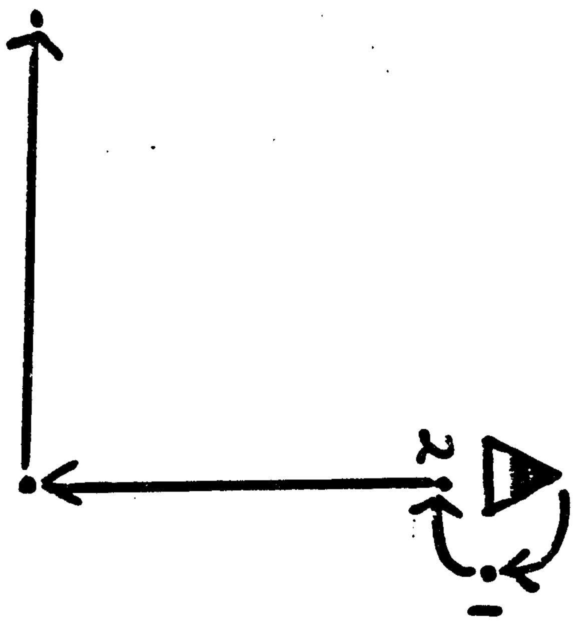
Training and Test Cards



5a



6b



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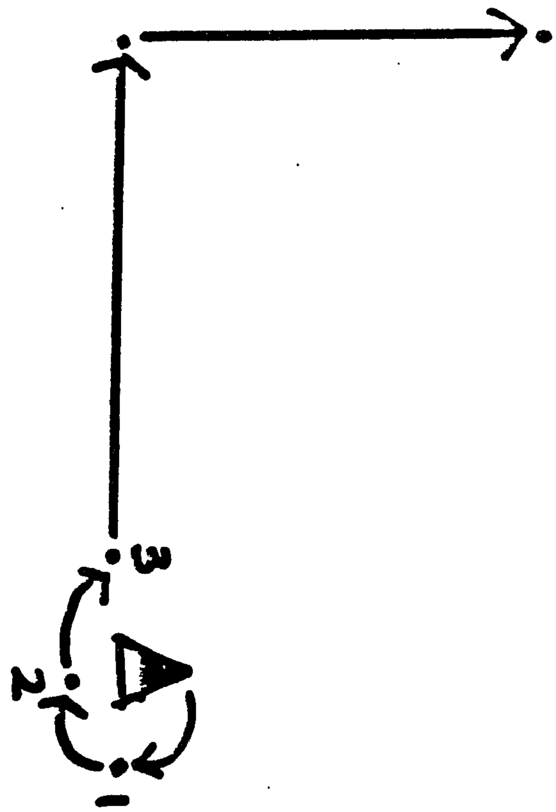

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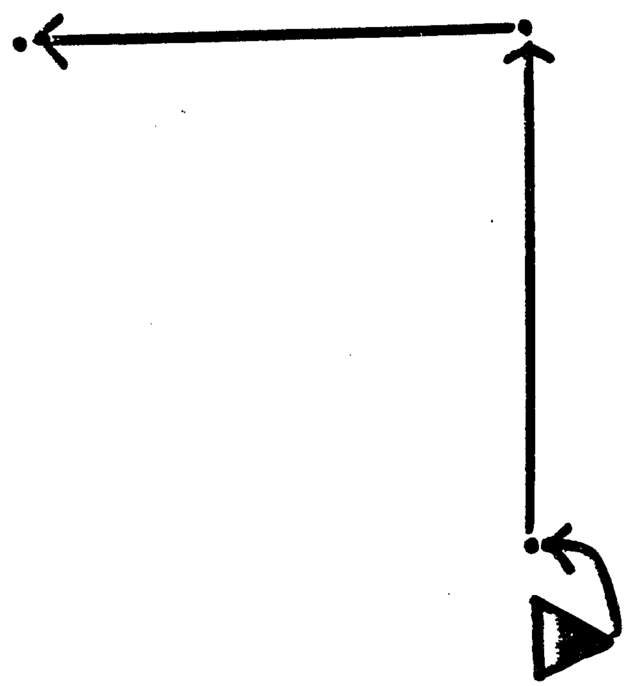

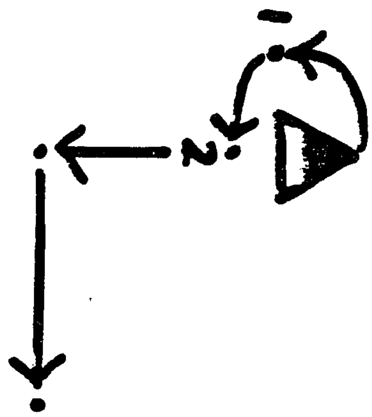

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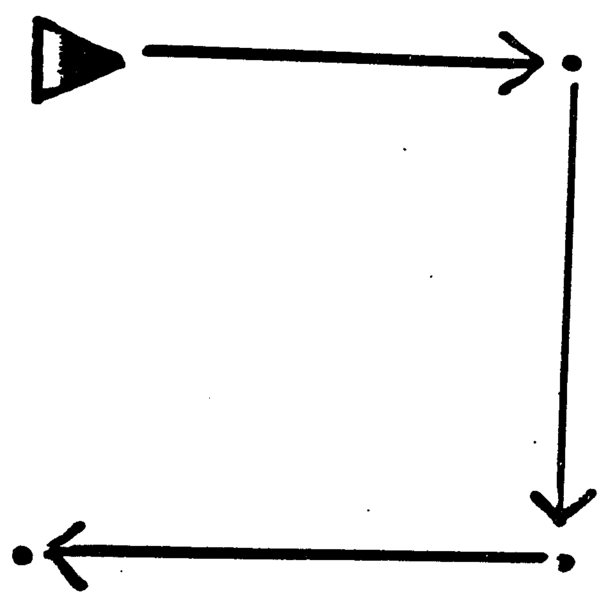

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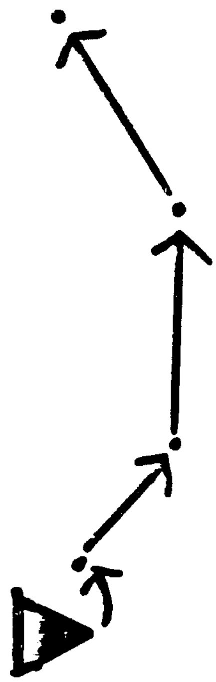
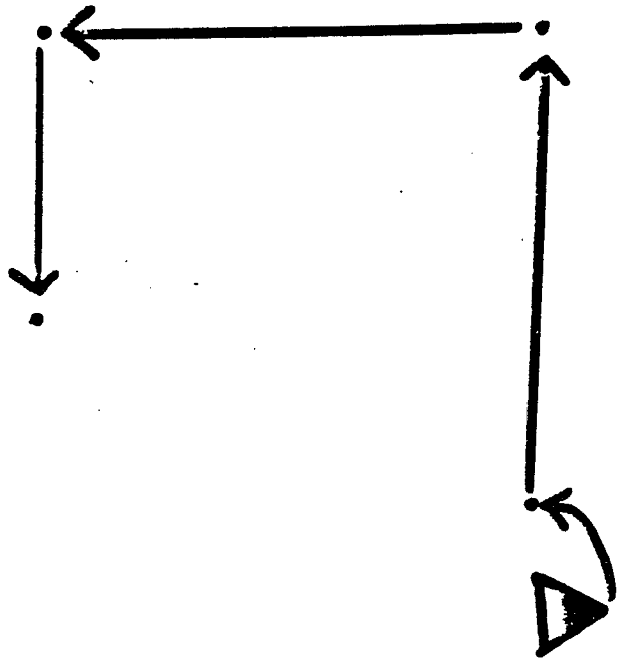


14a



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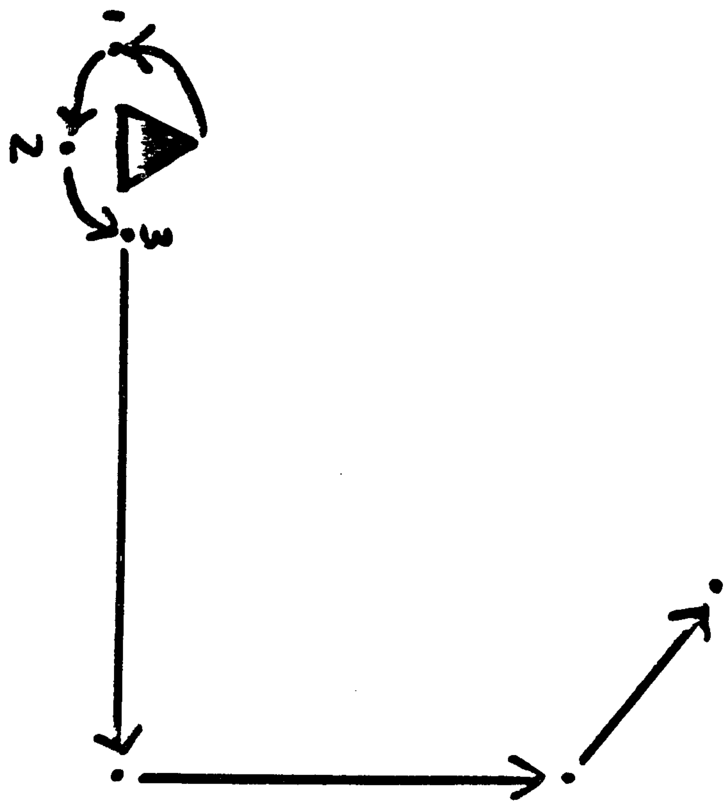

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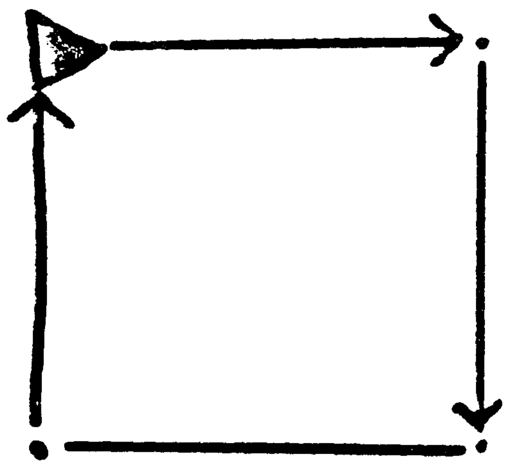

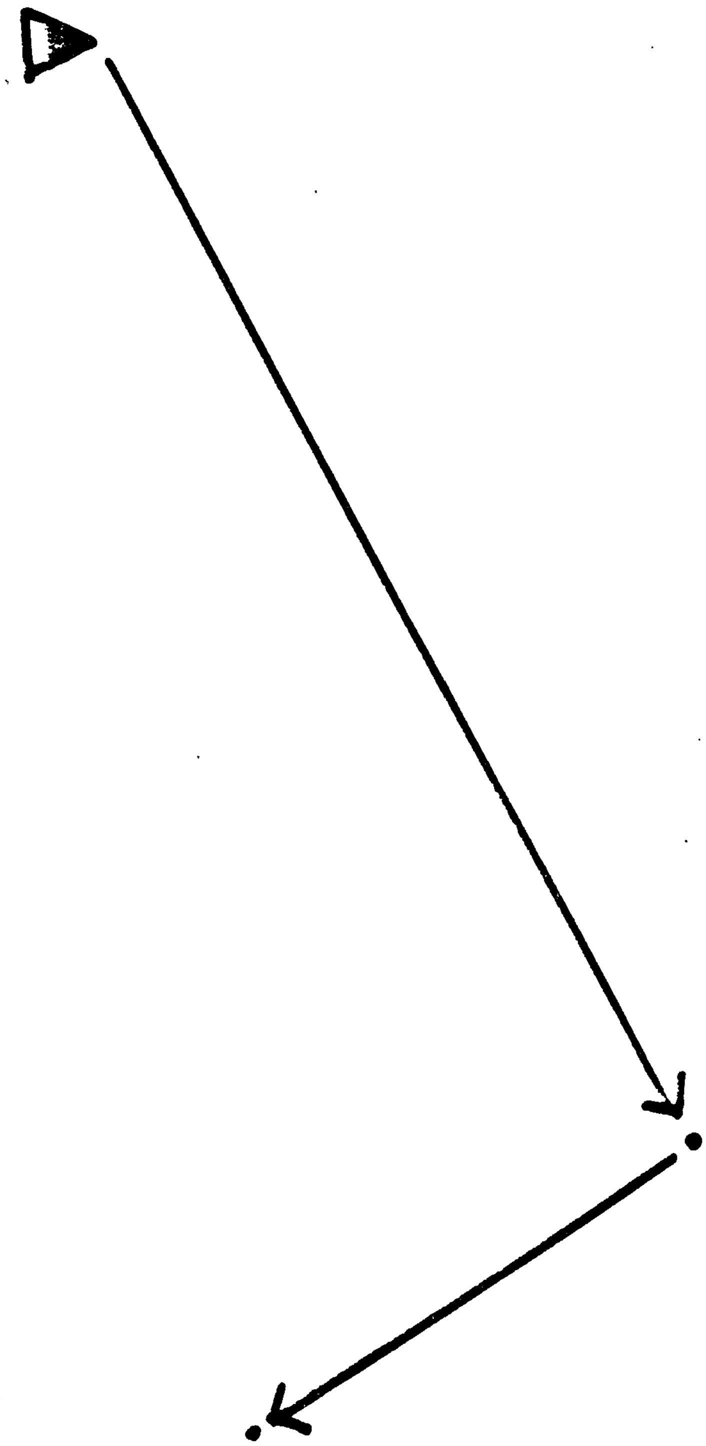

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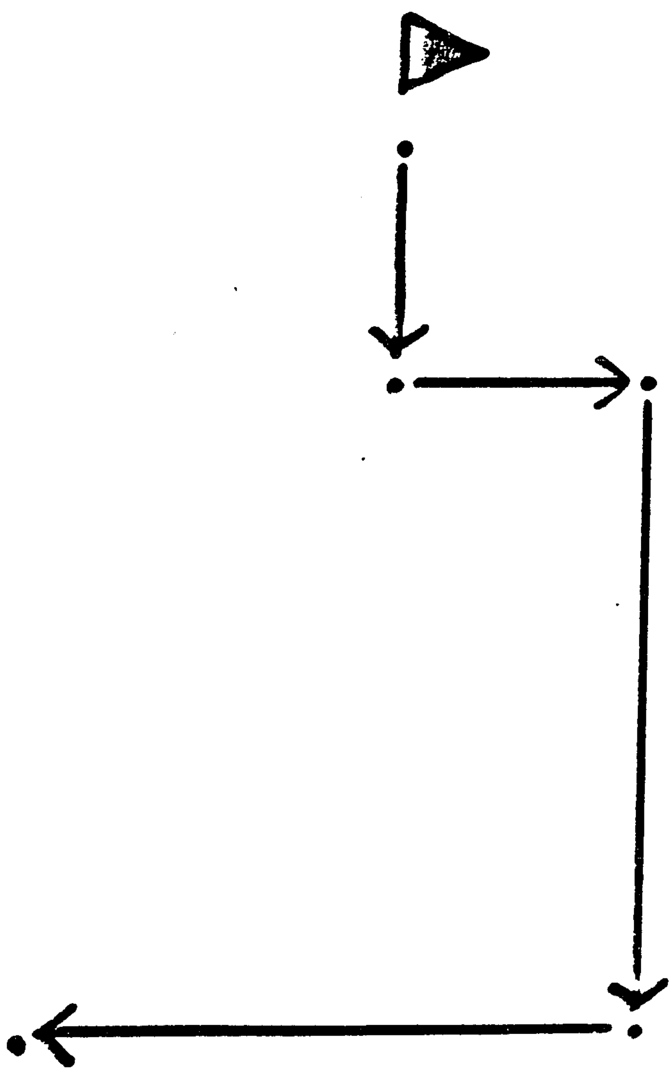

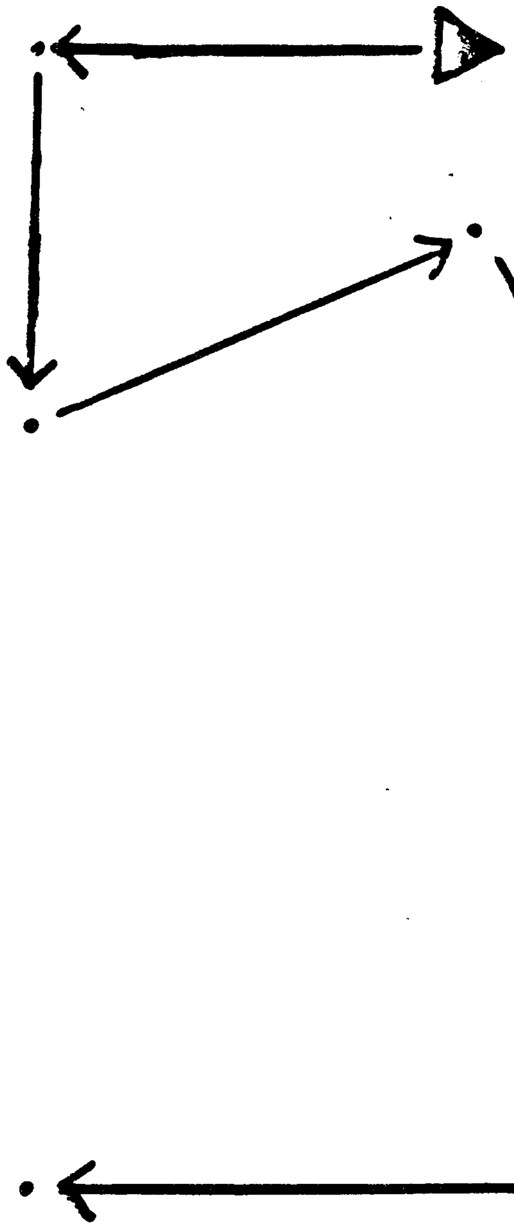

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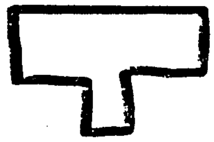

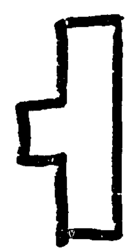

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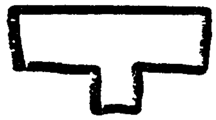

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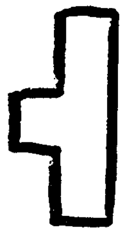

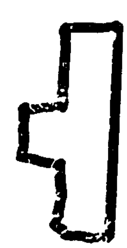

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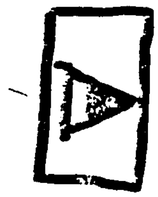

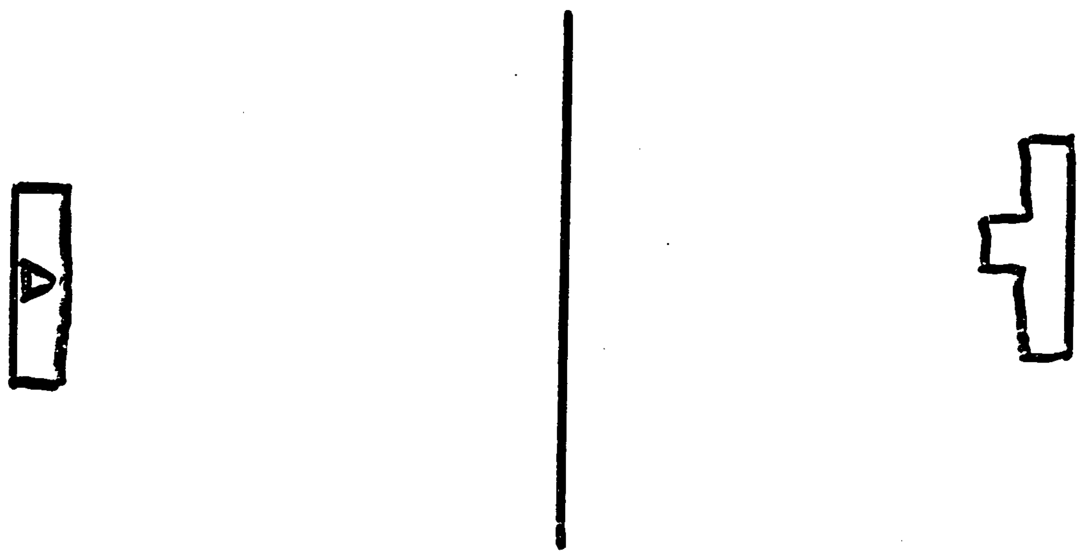

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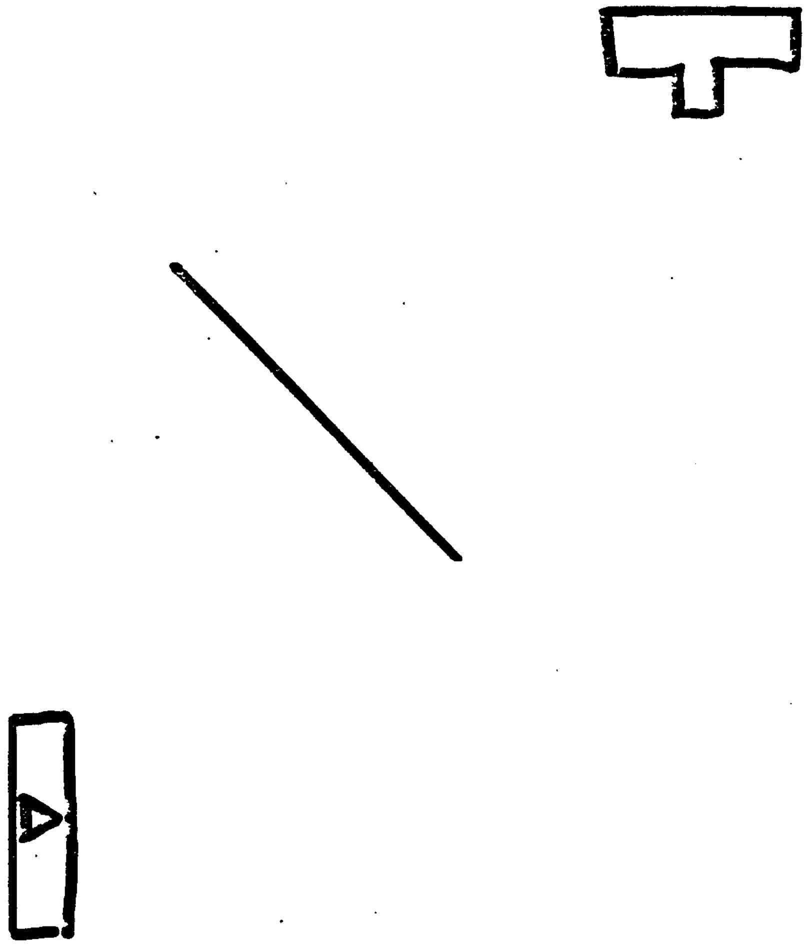

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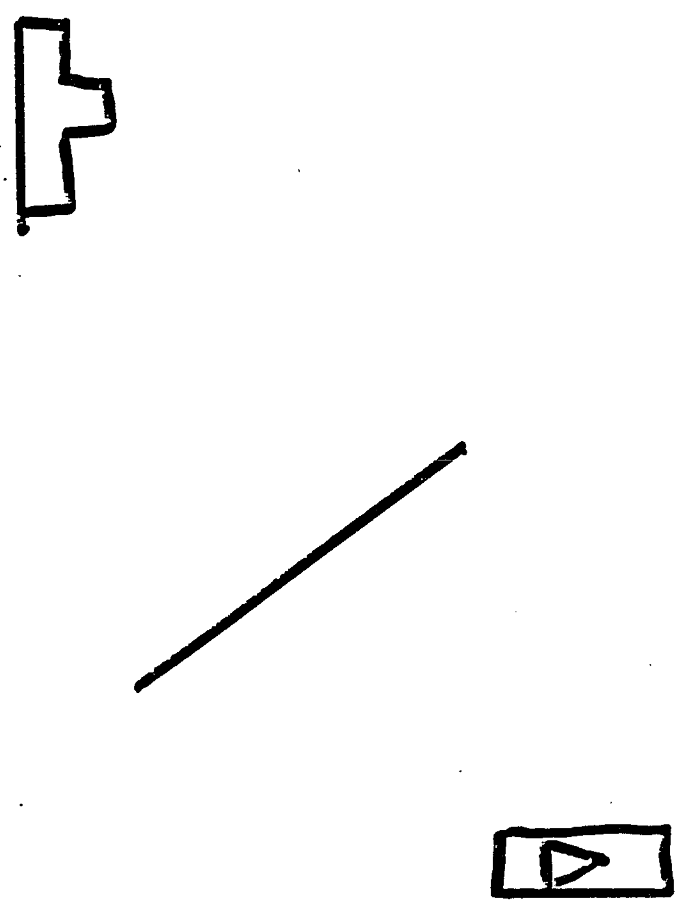

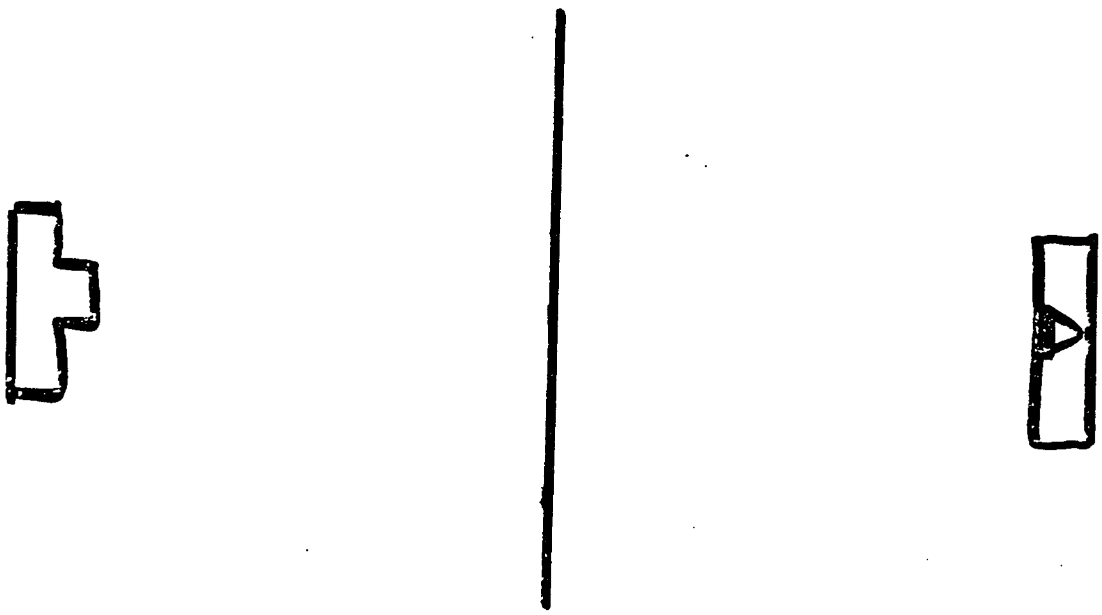

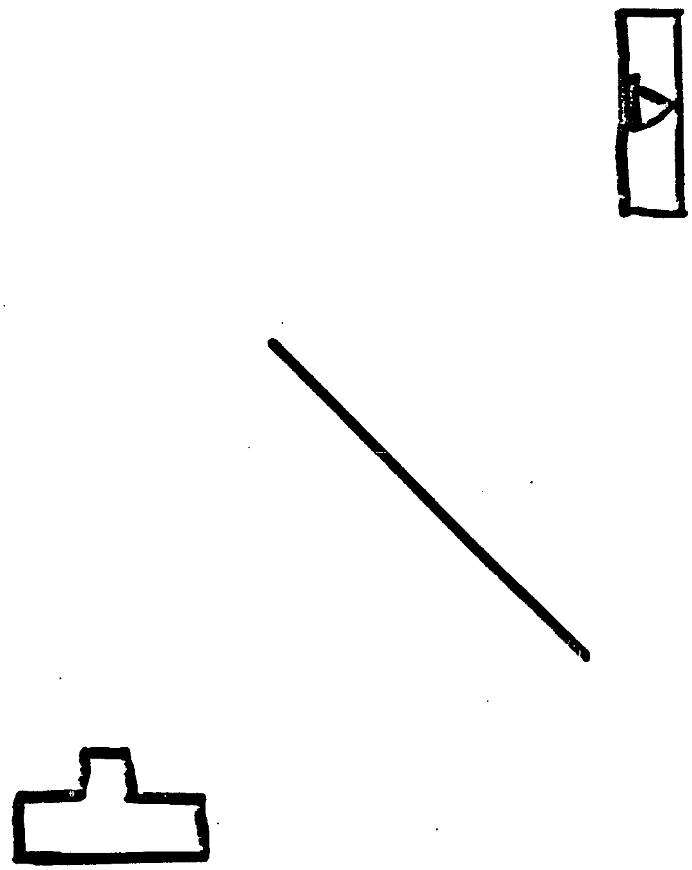

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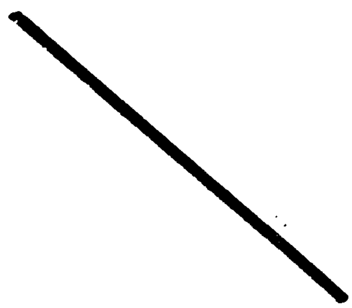

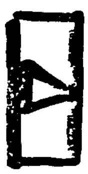

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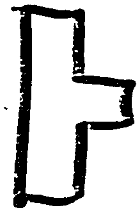

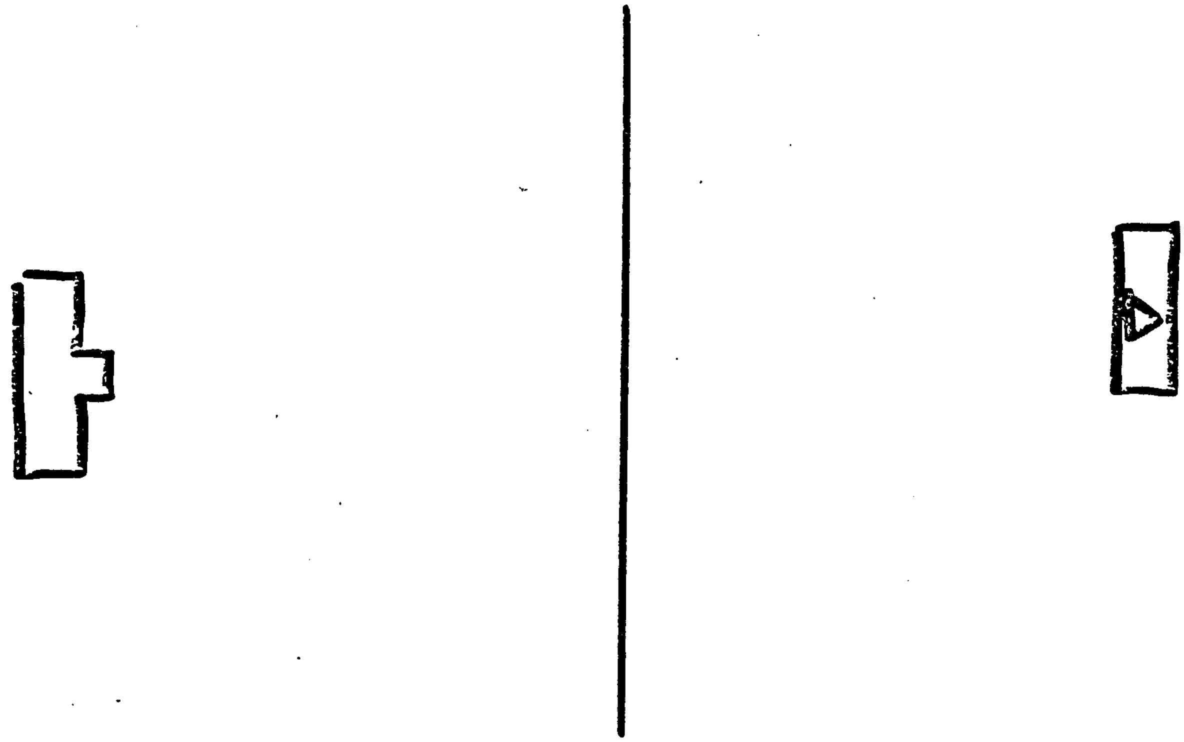

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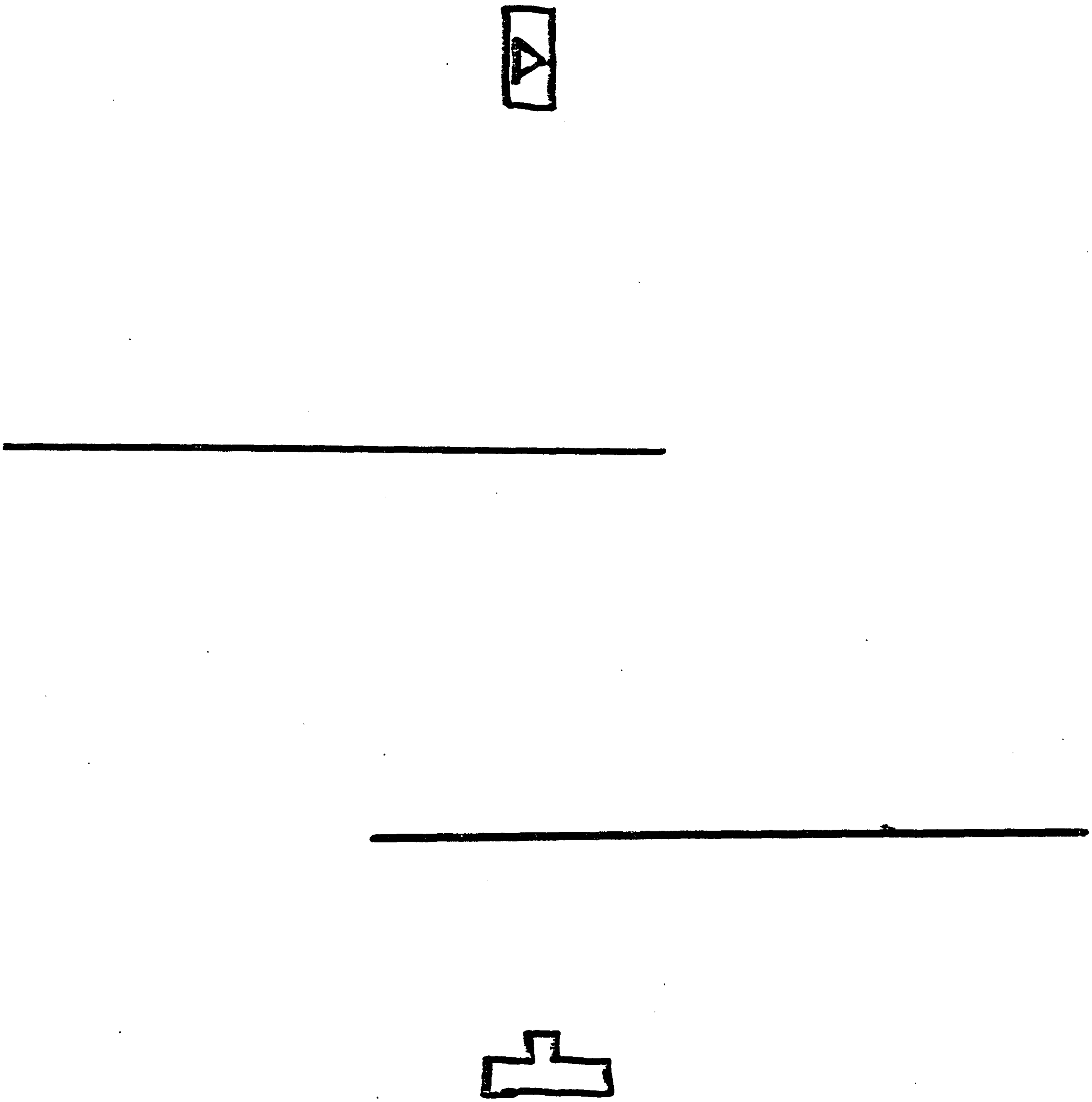

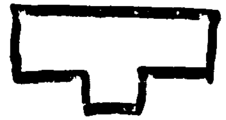

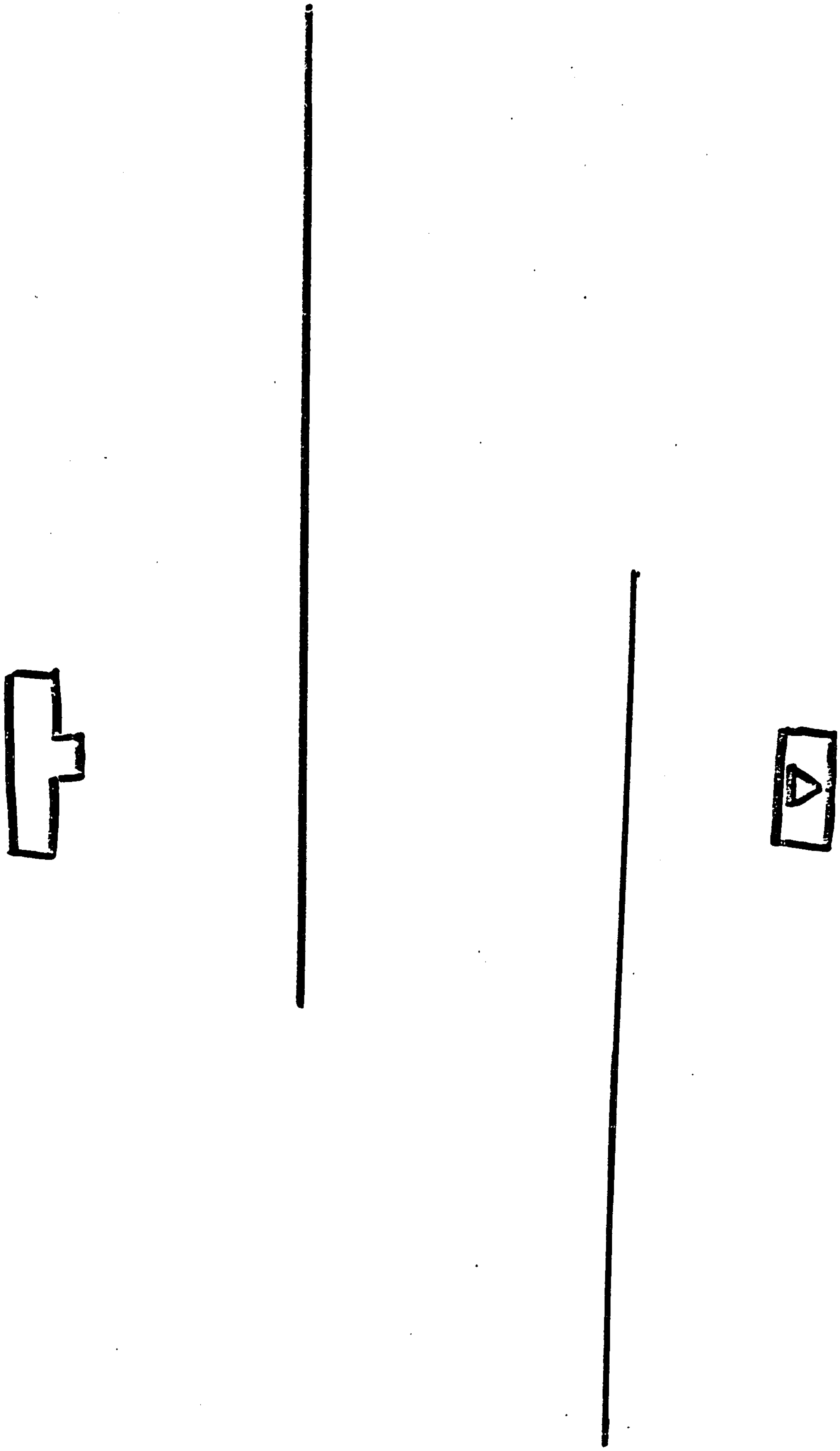

Appendix E

Score Sheet

Score Sheet

Name ______________________ Date ____________ Tutor ______________

ID # ______________________ Sex ____________

CARD #	Turtle Steps # Large	Small	(RT or LT) Angle(s)	Error	Time	*Help	Date Successfully Completed

* Help: I = Investigator
V = Verbal
M = Manipulative

Appendix F

Code Sheet

TEACHER BEHAVIORS

CODE SHEET

Subject ID # ________________

Teacher Age Category (TAC) _Same-age Near same-age College age_________

Week # ________________

Day # ________________

Session # ________________

Type of Teacher Behavior	Frequency
1. Elicit	
2. Direct	
3. Inform	
4. Initiate	
5. Re-Initiate	
6. Check	
7. Repeat	